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PROCEEDINGS

American Society of Sugar Cane Technologists

Volume 16 – Papers for 1969

December, 1969

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American Society of Sugar Cane Technologists

Volume 16 – Papers for 1969

December, 1969

FOREWORD

This is the sixteenth volume of Proceedings of the Society which has been published since its founding in 1938.

The first volume published in 1941 included papers presented during 1938, 1939 and 1940. Mr. Walter Godchaux, Jr., the then Secretary-Treasurer, edited that edition.

The second volume published in 1946 included papers presented during 1941-1945 inclusive. Dr. E. V. Abbott, Secretary-Treasurer, edited that edition.

The third volume published in 1953 included papers presented during 1946-1950 inclusive. A fourth volume was published in 1955 and presented papers for the years 1950 through 1953. Volume five contains papers for the years 1954 and 1955. The sixth volume included papers presented during 1956. The third through the sixth volumes were edited by Dr. Arthur G. Keller.

The seventh volume, which is in two parts, 7A and 7B, contains papers presented during 1957 through 1960 inclusive. The eighth, through the fifteenth volumes contain papers presented during 1961 through 1968, respectively. These volumes, as well as this, the sixteenth volume, which includes papers for the year 1969, have been compiled by the writer.

Denver T. Loupe
Denver T. Loupe
Secretary-Treasurer

December, 1969

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THE DEVELOPMENT AND USE OF THE UNITED STATES SUGAR CORPORATION MECHANICAL CANE HARVESTER

Joseph P. Sexton, Clewiston, Florida

Florida, like most sugar producing areas of the world, has its own unique problems as far as the mechanical harvesting of sugar cane is concerned. A large percentage of Florida cane is recumbent, particularly after a good growing season. The season for this recumbent cane is the heaviness of the cane coupled with the soft ground, and at times, wind. This recumbent cane seems to hug the ground as it grows. It is not uncommon to have one stalk with its top three feet above the ground, laying across one row entangled with the next row. (See Picture 1)

Erecting this cane is practically impossible, as attempting to do so often results in pulling up the stubble from the soft ground.

This is the main reason the erecting type cane harvester will not work successfully in Florida cane.

In 1964, our Company decided it would be to our best interest to develop a harvesting machine that would work under our conditions. One major requirement was that the machine harvest both erect and recumbent cane, since both types must be harvested in varying proportions as the season progresses. Another requirement was that the harvester fit into our existing system of cane handling, so as to disrupt the system as little as possible if we did gradually go to mechanical harvesting.

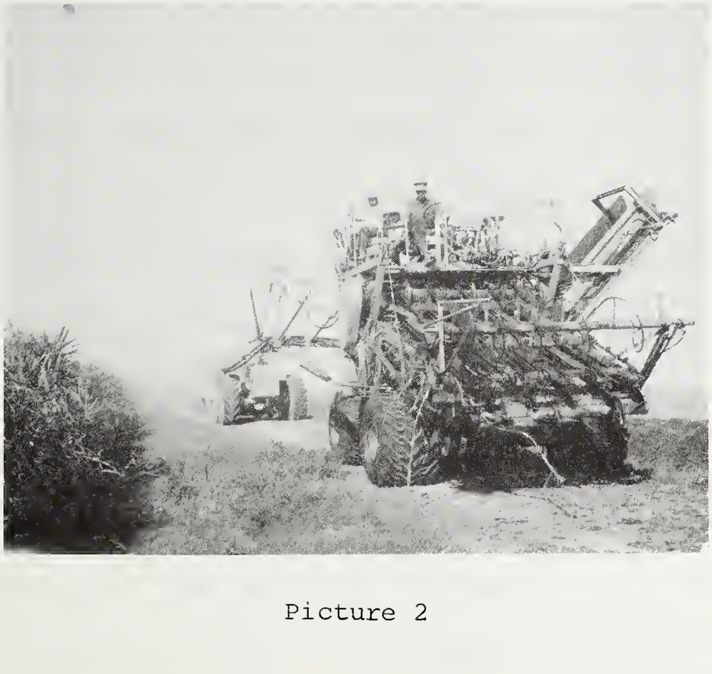
The machine that resulted is an outgrowth of our continuous loader. (See Picture 2) It would probably best be described as a top-cut-chop-load sugar cane combine. It travels around a cane field in a clockwise direction, with the unharvested cane to it right, discharging the harvested cane to its left. In order to harvest both erect and recumbent cane, it was decided to lay down the erect cane, so this cane would enter the machine like recumbent cane. This is done by means of an auger mounted on the front of the machine. The auger attempts to lay down the standing cane perpendicular to the direction of travel of the harvester. The auger does not accomplish this completely, but does start it enough in that direction so that when it is cut by the ground knife, the stalk will fall down properly. A side knife cuts any cane that lays down enough to become entangled with the next row.

The topping is accomplished by mounting a topping device consisting of gathering chains and cutting disc on the right side of the harvester. This tops the row of cane next to the row that is being harvested. This topping device does a small amount of erecting, and is controlled by an operator who regulates the topping height according to the cane. The severed tops are discharged to the rear of the machine, where they will not be picked up by the harvester on its next round trip.

In recumbent cane, a large percentage of the tops are left on the cane stalk, due to the unevenness of the tops in relation to the ground. At the present time, men are put in the field to cut off the tops that the machine topper could not get. These men have an assigned distance to cover while the harvester continues on around the field. They cut the tops and suckers from the exposed row of cane.

The harvester has a cutting device at the top of the gathering conveyer that cuts the cane into short pieces, regardless of the direction the cane enters the device. These short pieces are then delivered into a train of wagons that travel along the side of the harvester. These are the same type of wagons that are used in our present cane handling system. This arrangements allows us to

Picture 1



Picture 2

handle the cane from this point in the same manner as we normally do.

Since we have been experimentally harvesting cane, we have found several things that will aid this operation considerably. A level, smooth field is one of the most important factors. This allows for closer cutting to the ground without getting to the stubble and dirt. The more recumbent the cane, the more important is close cutting, as a good percentage of the cane is within one or two inches of the ground.

We have planted several fields that were especially prepared for the harvester. These fields are 1/2 mile long and 400 feet wide. We have 40 feet between the fields lengthwise, and ample head land for turning around. We find this type field allows for cleaner burning of the cane, as very little back-firing has to be done. There is an irrigation ditch between each field, which aids in fire control, as this muck land will burn when very dry. The long rows also facilitate continuous operations, with very little time spent in turning around. The opening between the fields also allows the harvester to begin work with no preparation other than burning being done to the field. Our harvester can normally harvest one 22 acre field in three 10 hour working days.

We have found the way to get maximum production out of a harvester is to have a continuous operation. Stopping, starting and many short waits will reduce the out-put of a harvester considerably. Every effort is made to keep the harvester moving.

We found one of the major problems produced by mechanical harvesting in Florida is the removal of trash and tops. We find the added trash increases our hauling requirements, not only for the additional trash, but also because we do not get as much weight per cubic feet in our transporting equipment. The tops of cane, of course, also affect mill operations.

Our first attempt to remove the trash is by trying to get a good burn. The narrow fields seem to help. We have also experimentally sprayed some fields with paraquat in order to kill the leaves and tops, and improve burn. These experiments look good, but the tolerances for sugar cane have not been established for labeling purposes, so it has not yet received official approval by the Food and Drug Commissions. The topping device on the harvester and the men working on the exposed topped rows also remove trash and tops, but this is not as good as we would like. Frozen cane, which we occasionally will have to harvest, will present further problems.

At the present, we have several experimental pieces of equipment that are being tried to help clean the cane, using air, stripper rolls, beaters, brushes, and vacuum. We have, so far, not developed what we think would be a practical cleaner, but we have not given up.

Our present thoughts are that a dry cleaning operation would be the best. We also feel that cleaning cane in the field would be the ideal situation, but we are not convinced this would be practical.

We feel we have made much progress in the mechanical harvesting and handling of sugar cane in our Company, but we do not feel we are in any position, as yet, to abandon our present system for mechanical harvesting, as there are many problems still to be overcome.

BURNING BAGASSE

Victor J. Baillet
Caldwell Sugars Cooperative, Inc., Thibodaux, La.

Burning of bagasse has presented those of us unable to sell the material with many problems. Primary among these problems has been that of disposing excess bagasse beyond the steam generating needs of the factory. Difficulties here are compounded when handling cane with a large volume of green trash - or during a rainy spell when considerable quantities of field soil accompany the cane.

Most of the factories meet the problem of excess bagasse disposal by blowing the material to an open storage pile several hundred yards from the factory where it is burned. This method of handling bagasse has been cited as unsatisfactory in a recent letter from the Louisiana Air Control Commission.

In view of the above, I would like to analyze some factors which affect the burning of bagasse in the furnace, and to discuss certain areas where furnace performance might be improved.

The two major types of furnaces for bagasse burning in Louisiana are:

1. The spreader stoker with dumping grates.
2. The cell-type furnace in which the cells may be round, oblong, or horseshoe.

The Spreader Stoker Furnace with Dumping Grates

Here the bagasse is blown or mechanically projected into the hot furnace, drying, then partially burning, and then completely combusting as it finally passes over the grates.

There is mixed opinion as to the ability of this furnace to burn large amounts of bagasse under muddy cane conditions.

For best results the combustion air has to be preheated - as was anticipated in the original design. The bagasse combustion is easy to control. However, more gas consumption is required, since auxiliary burners in addition to the main burners are often used to sustain and improve the bagasse combustion.

The main advantage in Louisiana of this type of furnace besides its ease of operation, is simplicity in cleaning. Conveyors may be readily installed below the grates to collect and carry away the ashes.

Cell-Type Furnace

The cells can be located in an extension of the furnace in front of the boiler. This is the Dutch oven type design, which allows a lower head setting but involves more burdensome cleaning of the combustion chamber below the boiler, and is more expensive in cost and maintenance because of the suspended arch over the cells - this arch extending by a nose into the combustion chamber.

In the new designs, the cells are located directly below the tubes. One of the original types which employed this design seems to be the Ward furnace. Obviously the boiler has to be set higher, and the distance from the top of the cells to the first pass through the tubes should be not less than 14 feet to allow full combustion of the gases before reaching the relatively cold tubes.

The bagasse burning capacity of each cell is a function of the inside perimeter and not the cell area. For this reason greater efficiency would be obtained with more medium sized cells than with fewer large cells.

The shape of the cells is important, and they should not be too elongated, as the bagasse heap is roughly conical.

The total opening of the tuyers and their location is critical. Generally, they are too numerous and extend to too great a height. Properly 85 to 90 percent of the total opening should be concentrated in the first 12 to 15 inches from the bottom, and the remainder in a single row of small tuyers about two to three feet higher. This last row activates the combustion of the gases produced by the bagasse burning.

The height of the bagasse heap is also important, and it should be related to the width of the cell. Generally, four to six feet maximum is the best for good combustion. It is an error to fill the cells too high.

There is a definite maximum amount of bagasse which a cell can burn. Hence, a reference mark should be made to correspond to the optimum opening of the bagasse trap door. Additionally, it should be impressed on the bagasse "burner" that any change in the bagasse feed rate should be progressive in order to maintain good combustion.

It is a good practice to have an air pressure gauge (0 to five inches of water) as reference for the optimum air pressure. The desired reading is, of course, found by experience.

A useful feature is to have all the forced draft blower turbines supplied by steam from a single header. Common header pressure is maintained constant by a steam pressure regulator. With this provision, the furnace operation is not affected by fluctuations in steam pressure.

The type and location of the gas burners affect the bagasse combustion. The burners best suited to supplement the bagasse heat are those with their own proportioning and mixing devices. The burners should not be located in such a way that their flame is in the path of the falling bagasse as this tends to disperse the bagasse. Nor should the burner flame be directed to the top of the bagasse heap, as this interferes with the normal combustion of the bagasse which is from the bottom up.

For good bagasse combustion, the cells must be cleaned periodically - at least once every six hours, and during a muddy spell even every four hours. A good practice is to establish a regular cleaning schedule with an even time spacing. This has the advantage of having the other cells in full combustion when one is being cleaned.

After a cell is cleaned and the bagasse has been let in to form a small heap, throwing a can of kerosene or tractor fuel at the base of the bagasse quickly starts its combustion.

FULL PAN SEEDING OF LOW GRADE STRIKES

A BRIEF REVIEW

T. R. Ray, Inc., Baton Rouge, Louisiana

The full seeding method of graining low grade strikes was developed over a period of years beginning in the early 1930's and reflected the efforts of researchers in many parts of the world. By the late 1940's, the method had become well established and was described by Eugene C. Gillett[1] in his classic booklet, "Low Grade Sugar Crystallization," in 1948. This booklet, which was published by the California and Hawaiian Sugar Refining Corporation, Ltd., described a practical method which fabrication superintendents in raw cane sugar factories could use to achieve tremendous improvements in graining low grade strikes. It offered many advantages over the "shock" seeding method or the "waiting" method of graining. The grain obtained with full seeding was more uniform and better shaped and the results were always reproducible. Fabrication superintendents could always be sure of obtaining the proper amount of grain of the proper size through the full seeding technique. Furthermore, full seeding offered a much more rapid way of graining low grade strikes than any other method.

It was thought when the full seeding method was finally perfected that it would eventully supersede all other methods for graining low grade strikes in raw cane sugar factories and for graining low purity remelt strikes in sugar refineries. It did, indeed, spread rapidly throughout the world. Its acceptance by the raw cane sugar factories, however, has not been nearly as rapid or as extensive as its acceptance by the cane sugar refineries. At the present time, less than 10% of the cane sugar factories in Louisiana use the full seeding method and it is probably in use in fewer than 10% of the cane sugar factories in the Western Hemisphere. Recently, however, interest in the technique has revived. This is due mainly to the new quality standards for raw sugar and to the introduction of continuous centrifugals for high grade sugar - both of which place a premium on large, uniform crystals. Since the advantages of full seeding are obvious to all those who are familiar with it, it would seem that a brief review of the technique would be of interest to those sugar technologists who are not now using it. The basic technique is still not well understood by the majority of the fabrication personnel in the raw cane sugar factories, some of whom have confused it with the shock seeding method of obtaining grain.

In the following discussion, all purities are apparent purities, vacuums are stated in inches of mercury, and boiling point rises and temperatures are in degrees Fahrenheit.

A solution is saturated when no further sucrose can be dissolved into it at a given temperature. If the solution is then concentrated by evaporation or cooling, the solution becomes supersaturated. A supersaturated solution contains more sucrose in solution than can be dissolved into it at the given temperature. The degree of supersaturation can be defined in either of two ways. It may be defined as the concentration of the given solution in parts of sucrose per 100 parts of water divided by the concentration in parts of sucrose per 100 parts of water of a saturated solution at the same temperature and purity. As sucrose is dissolved in water the temperature of the boiling point of the solution increases. This elevation of the boiling point due to the sucrose dissolved in the water is referred to as the boiling point elevation or the boiling point rise. The boiling point rise is exactly proportional to the amount of sucrose dissolved in the water. Thus, the degree of supersaturation of a sugar solution may also be defined as its boiling point rise divided by the boiling point rise of a saturated solution at the same temperature and purity.

Figure 1[2] shows supersaturation curves for pure sucrose for supersaturations of 1.0, 1.20, and 1.30. Below the curve of 1.0 supersaturation, the solution is unsaturated and if additional sucrose is added to the solution, the sucrose will dissolve. Above the 1.0 supersaturation line the solution is supersaturated, but, if no sucrose crystals are present, no sucrose will percipitate from the solution until the labile zone at a supersaturation of 1.30 is reached. The range between supersaturations of 1.1 and 1.2 is referred to as the metastable zone. In this region no new sucrose crystals will form but existing crystals will grow, sucrose depositing from the solution onto the existing crystals. Between supersaturations of 1.2 and 1.3, the solution is in the intermediate zone. If the solution contains sucrose crystals, then additional new crystals, then no crystals will form in the intermediate zone. If the solution is further concentrated into the labile zone above 1.30, then new crystals will form spontaneously whether or not existing crystals are present. It should be emphasized that Figure 1 holds true only for pure sucrose dissolved in water.

These curves can be used to explain the three major methods of graining low grade strikes. In the waiting method, a sugar solution must be concentrated by evaporation into the labile zone before crystals will form spontaneously. At this high concentration, crystal formation is almost explosively rapid. Control over the formation of the crystals and the amount of crystals obtained is impossible. In the shock seeding method the solutions are concentrated only into the intermediate zone. At this point, a small amount of powdered sugar crystals are introduced into the pan and their presence provokes the formation of large numbers of new sugar crystals. Because the concentration in the intermediate zone is lower than that in the labile zone, the formation of the new sugar crystals is slower than in the case of the formation of crystals by the waiting methods. For that reason, the shock seeding method is subject to more control than the waiting method. However, the formation of sugar crystals is still far too rapid to be adequately controlled and wide variations in quantity and quality of crystals are apparent from one grain formation to the next.

In the full seeding method of graining low grade strikes, the sugar solution is concentrated only into the metastable zone and a full crop of seed crystals is introduced into the pan. One seed crystal is introduced into the pan for each crystal of sugar in a finished low grade strike. No new crystals are ever formed in the pan. All the crystals which finally are found in the "C" strikes are introduced into the pan in the form of an extremely fine powder. Since no crystals are ever formed in the vacuum pan at any time, the control over the quantity and size of the sugar crystals produced can be closely controlled. The amount of seed to be introduced an be calculated fairly exactly and results in actual practice are closely related to the calculated amount of seed required. It is possible to control the quantity and the size of the "C" sugar crystals by controlling the amount of seed introduced into the graining charge. It is the only graining method which permits this control. It is also the only graining method which will consistently give well shaped, uniform size "C" sugar crystals, and it is certainly the quickest method of graining.

In order to use the full seeding technique successfully it is necessary to understand the conditions which affect the amount of the "C" sugar seed required and the conditions which affect the growth of the seed in the pan.

The system used in each factory for making "C" strikes must be studied closely in order to determine the amount of seed required. In his original work, Gillett[1] grained each "C" strike individually and indicated that for best results the graining charge should not exceed 25% of the volume of the finished "C" strike. Later Gillett and Kenda[3] experimented with graining for more than one "C" strike. At the present time, most raw sugar factories are better equipped with seed tanks and may grain for as many as nine or more strikes at one time. For instance, Erath Sugar Factory at Erath, Louisiana, makes grain in a small 450 cu. ft. coil pan with a graining volume of 150 $ft.^3$, but the "C" strikes are finished in a calandria pan of 1100 cu. ft. Enough grain is made at one time in the 450 cu. ft. pan to provide sufficient footings for six "C" strikes, each of 1100 cu. ft. Thus, 6,600 cu. ft. of "C" strikes are produced from one graining charge of approximately 150 cu. ft. in volume. The graining charge when the seed is introduced into the pan is only 2.27% of the finished "C" massecuite volume. This is more or less typical of the modern trend towards preparing sufficient grain at one time for a large number of "C" strikes.

The advantages are obvious. If grain is made for only three strikes at one time and the graining volume is approximately one-third the volume of the pan, then the graining volume is approximately eleven percent of the total volume of finishes "C" massecuite. The critical period at any graining operation, regardless of the method used, is the period immediately following the appearance of the grain in the pan. The grain is dispersed in the sugar solution and must be brought together very carefully in order to avoid melting some of the crystals and to prevent the formation of false grain or conglomerates.

The more concentrated are the crystals in the sugar solution the easier it is to bring the particles together so that normal pan operation can be resumed. Since each cubic foot of "C" massecuite contains approximately the same number of sugar crystals and since these crystals are added in the form of a seed in the graining charge, it is obvious that the smaller the graining volume in relation to "C" massecuite volume the more concentrated will be the seed therein. It is evident that with a graining charge of 2.27% of final "C" massecuite volume as compared to a graining charge of 11% of final "C" massecuite volume that the grain is approximately 5 times more concentrated to start with. Obviously, it is much easier and quicker at Erath to bring together the crystals than it would be at most factories in Louisiana. Another advantage of graining at one time for a large number of "C" strikes is that these footings are then readily available at any time they are needed for producing a "C" strike. Pan operations are rarely delayed waiting upon grain to be made.

The type and quantity of seed used, of course, has a direct bearing upon the quality of the "C" massecuite produced. In the early '30's, E. M. Berg, working at the California and Hawaiian Sugar Refining Corporation, Ltt. developed a method using refined granulated sugar as a seed footing for low purity remelt strikes. Eugene Gillett refined this technique and used a seed of finely ground fondant and icing sugar. Because of the extremely small particle size of the fondant and icing sugar only a relatively small amount was required for full seeding operations. Other authorities have recommended an even finer seed. They have gone so far as to suggest that the seed should be produced by prolonged ball milling of refined sugar in isopropyl alcohol to yield a seed having an average particle size of less than 5 microns. It is suggested that this specially prepared seed will be more uniform than commercially available powdered sugar from the sugar refineries. At the present time, the California & Hawaiian Sugar Company (successor to the California and Hawaiian Sugar Refining Corporation, Ltd.) make available commercially a fondant and icing type sugar which is especially made for pan seeding. The sugar has an average size of approximately 15 microns. In those countries where this sugar can be obtained readily, it would seem best to use the California & Hawaiian pan seed sugar rather than try to produce a special seed by prolonged ball milling or by other means. In Louisiana and in most cane sugar factories in the Western Hemisphere well trained laboratory personnel are rare. In most cases only the Chief Chemist has had any education and preparation for laboratory work. He is usually entirely occupied with other jobs and cannot devote time to the preparation of seed for low grade graining operations. The factory personnel on the pan floor, of course, are neither qualified nor have the time for such a job. Furthermore, because of the extremely fine particle size of the especially prepared seed, small variations in technique mean large variations in the number of particles introduced into the pan. It seems likely that greater error would be introduced trying to manufacture seed of extremely fine particle size than would be introduced by using the commercially available seed purchased from the California & Hawaiian Sugar Company.

If the average particle size of the seed is known, it is possible to calculate the amount of seed required. A typical calculation follows.

Assume:

"C" Sugar Crystal of 0.33 MM Side Length
Seed Crystal of 0.015 MM Side Length (California & Hawaiian Pan Seed Sugar)
Purity of Seed = 100
Purity of "C" Sugar Crystal = 100
Purity of "C" Massecuite = 59.0
Purity of Final Molasses = 29.0
95 Brix "C" Massecuite

Basis:

1,000 Ft^3 "C" Massecuite

Let X = Percent of Solids in Massecuite which enter "C" Sugar Crystals
C = Purity of "C" Massecuite
M = Purity of Final Molasses

Then:

$$X - \frac{100\ (C-M)}{100\ -\ M} = \frac{100\ (59.0 - 29.0)}{100 - 29.0}$$

$X = 42.25\%$

*At 95 Brix, 1 Ft^3 Massecuite has 89.539# Solids[4]
Solids in 1,000 ft^3 = 89,539#
Solids (and Sucrose, with 100 Purity Crystals) in "C" Sugar Crystals = 89,539# x .4225
Sucrose in "C" Sugar Crystals = 37,830#

$$\text{Wt. Seed} = 37{,}830\# \ \frac{(.015)^3}{(.33)^3}$$

Wt. Seed Required for 1,000 ft^3 = 3.55#

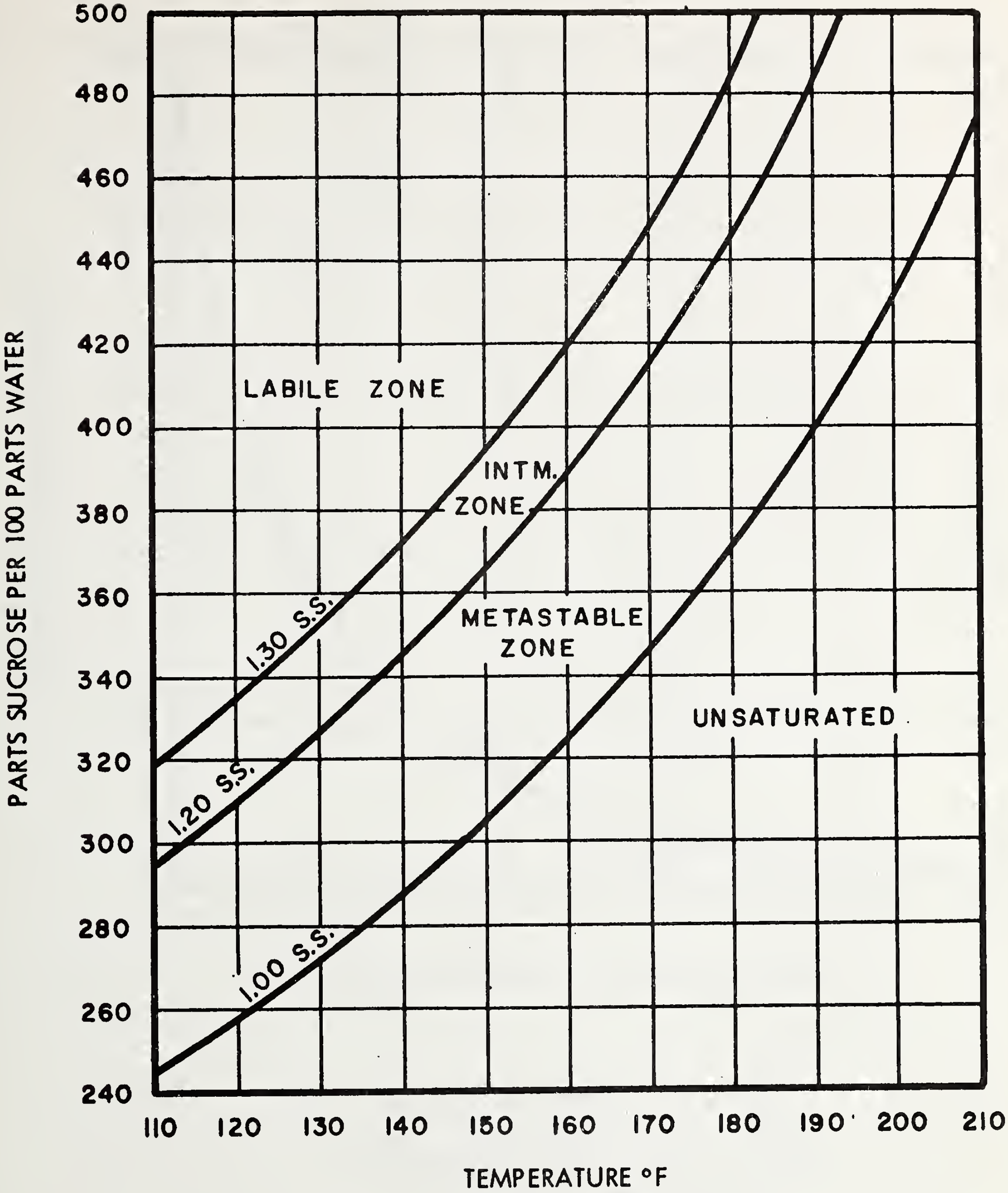
* Data for solids per ft^3 of massecuite are accurate at 27-1/2°C. only, whereas most "C" massecuites are purged at approximately 50-55°C. This discrepancy, plus the use of apparent instead of true purities introduces an error or approximately 1% into the calculation. But other possible errors (such as the difficulty of obtaining the true particle size of the seed) are of much greater magnitude so that the 1% error can be accepted in all practical work.

A "C" sugar crystal size of 0.33 MM has been assumed as being typical of Western Hemisphere operations. The calculated amount of seed may have to be adjusted in practice but if the seed is carefully weighed out each time, and if the technique is standardized in all details, then such an adjustment will be small. Erath, for instance, found it necessary to use 3.79# seed per 1,000 ft.^{3} of "C" massecuite instead of the calculated amount of 3.55# per 1,000 ft.^{3}

For Louisiana conditions, about 3.5 pounds of California and Hawaiian pan seed sugar is required for each 1,000 ft^3 of finished "C" massecuite. Usually, those few Louisiana factories that have tried to use the full seeding technique have not used nearly enough seed. A figure of 1 pound of seed per 1,000 ft^3 of "C" massecuite has usually been cited as being sufficient. But 1 pound is not enough for full seeding and additional grain must be formed in the pan, resulting in a badly mixed grain size. The above sample calculation can be used as a guide to calculate the approximate amount of seed required.

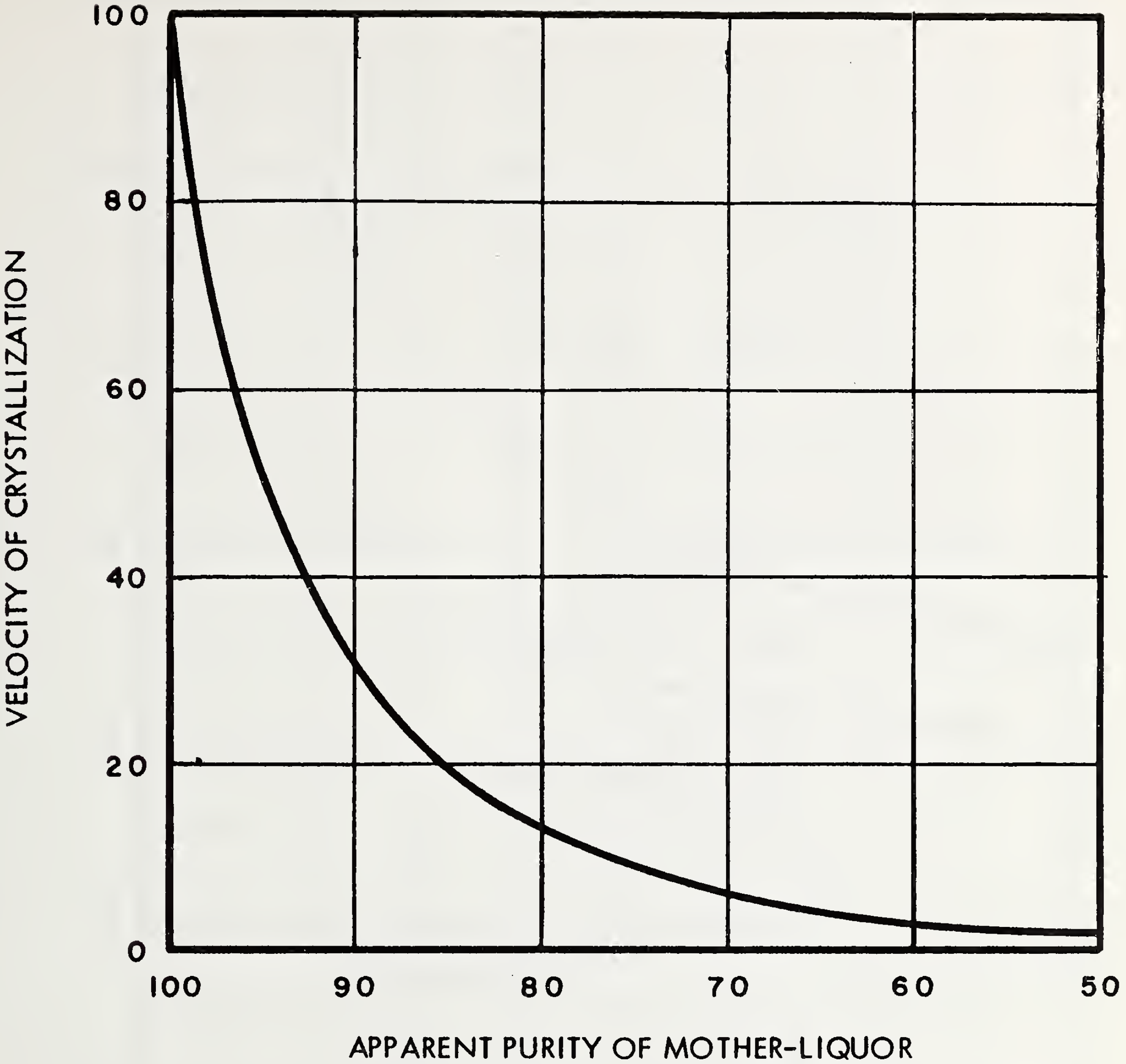
The seed should be mixed into a slurry with isopropyl alcohol (99% pure with a maximum water content of 0.5%) in the ratio of 1# of seed to 1 qt. of alcohol. This is mixed by an air driven laboratory type mixer in a small tank attached to the pan. Fabrication superintendents are cautioned to prohibit smoking or any other open flames on the pan floor during the time the seed is being mixed and before its introduction into the pan. Isopropyl alcohol is not highly flammable but it is foolish to take chances.

The purity of the graining charge is important in obtaining good control over the vacuum pan and, therefore, in obtaining well developed and uniform crystals. Originally, all graining was done in syrup at a purity of approximately 80 to 85. However, the introduction of supersaturation indicating instruments has facilitated the graining on lower purity materials and in later years the purities used in graining have tended to be lower and lower. The big disadvantage of using lower purity materials for graining is the reduced rate of crystallization. This is clearly illustrated by Figure 2[5]. The rate of crystallization at 80 purity and constant supersaturation is approximately 3-1/2 times the rate of crystallization at 60 purity. This tends to prolong the critical period between the introduction of seed into the pan and the time when the crystals have been brought together ready for normal pan operation. Other factors, however, counterbalance the effect of low purity on the rate of crystallization. It is generally agreed that the rate of crystallization varies according to the square of the supersaturation. At 80 purity, the supersaturation is limited to 1.25 but with 60 purity it may be raised to 1.5. Thus, the rate of crystallization at 60 purity is not as low as is generally believed. Furthermore, there are offsetting advantages to graining on low purity material which favor as low a purity as the boiling system will allow. Figure 3 shows the variation in supersaturation lines for variations in purity. The upper limit of the metastable zone for pure sucrose is approximately 1.2, but for 60 purity material the upper limit of the metastable zone is approximately 1.5. The sugar boiler, however, is as interested in boiling point rise as supersaturation because all supersaturation indicating instruments are based on measurement of the boiling point rise. Figure 4[6] shows that the boiling point rise increases as the purity decreases. Figure 4 shows very clearly the wide range of the metastable zone for 60 purity materials as compared to the narrow range for higher purity materials. It is this wide range of boiling point rise which makes the lower purity materials attractive for graining. It means that there is a wider margin of error for the pan operator to make mistakes and still not damage the crystals in the pan. For instance, at a constant boiling liquid temperature of 175° F., the boiling point rise increases from 17.2 to 21.8 as apparent purity drops from 80 to 60 for saturated solutions. But since the supersolubility of the metastable line also increases for a drop in purity, the safe boiling range is greatly increased as the purity is decreased. At 80 degrees, the safe boiling zone would only extend from 17.2 to 21.4 degrees, or only 4.2 degrees of boiling point elevation. At 60 purity material and the same vacuum, the safe boiling point elevation extends from 21.7 to 32.5. The difference in this case is 10.8 degrees of boiling point elevation or, in other words, 2-1/2 times the safe boiling range for an 80 purity material.



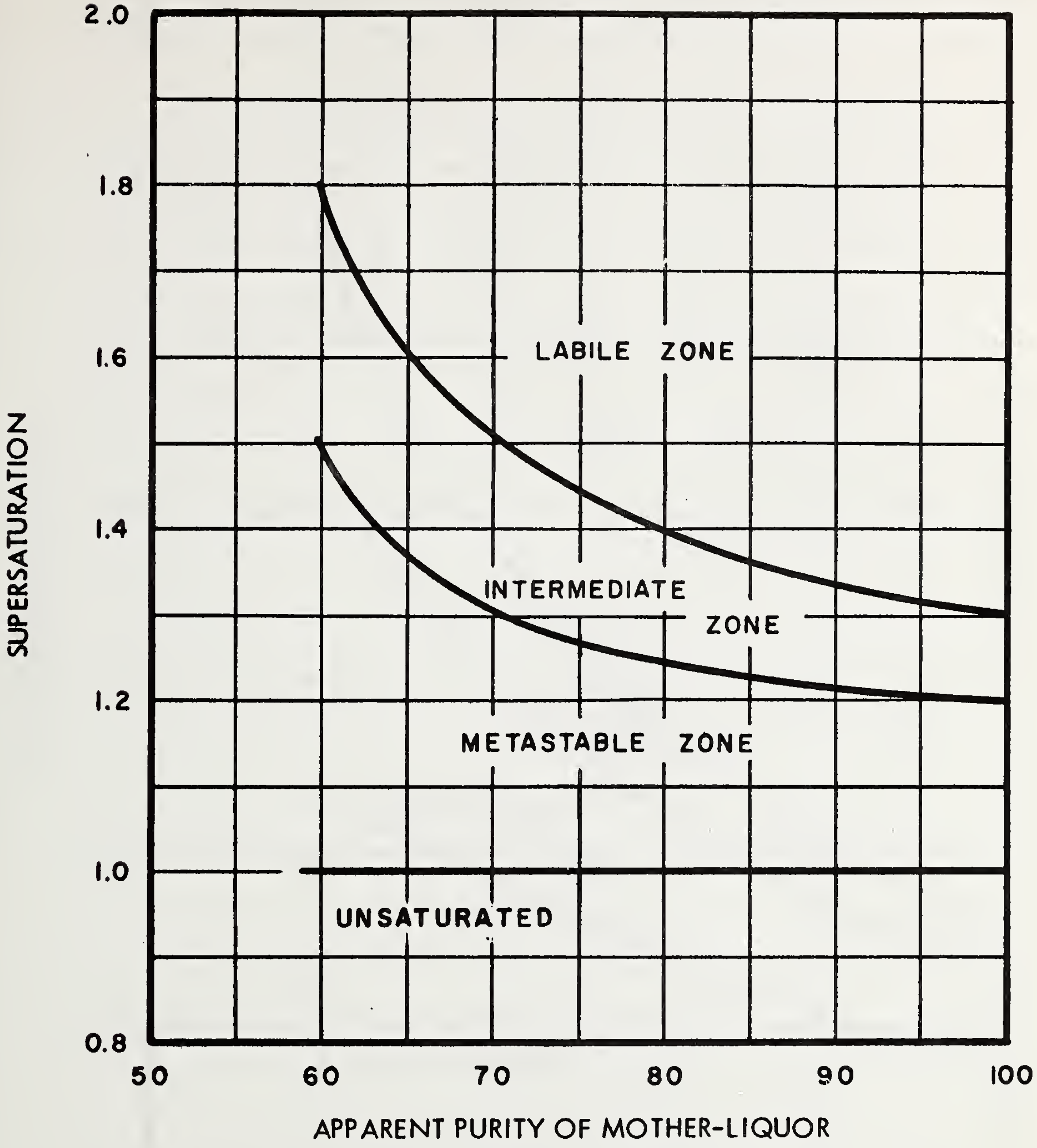
SUPERSATURATION CURVES FOR
PURE SUCROSE

FIGURE 1



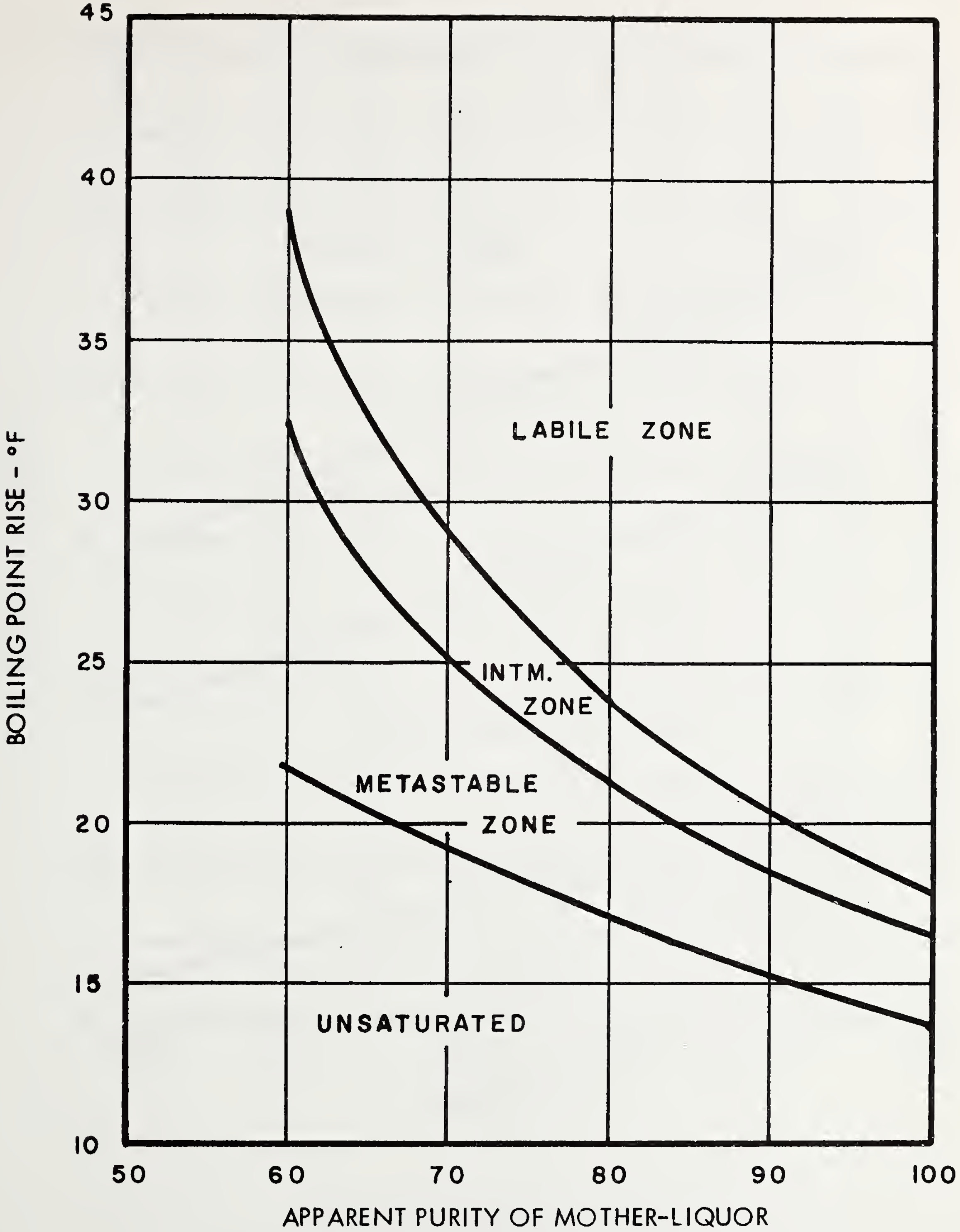
VELOCITY OF CRYSTALLIZATION
vs
APPARENT PURITY OF MOTHER-LIQUOR
AT CONSTANT TEMPERATURE

FIGURE 2



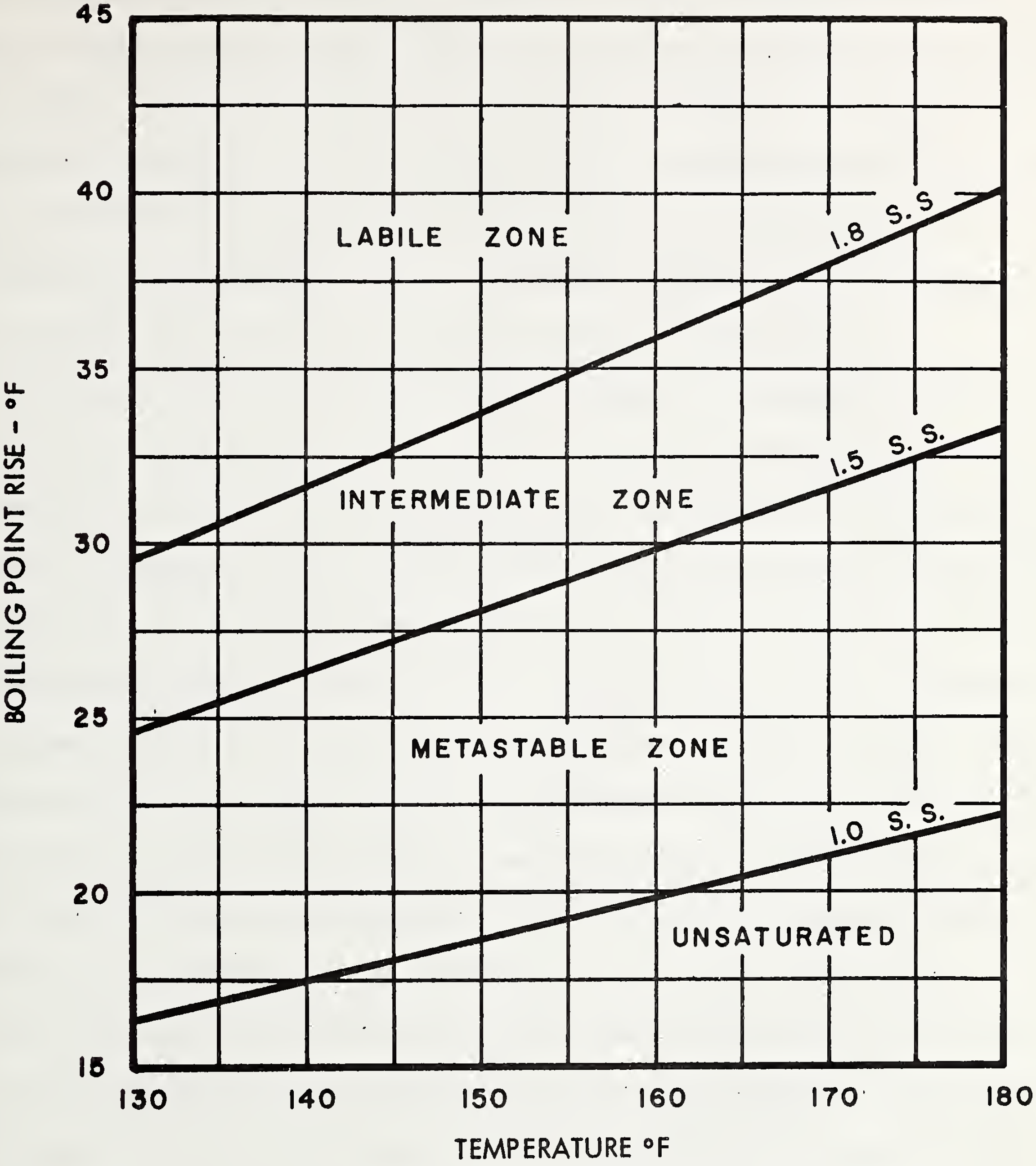
LOCATION OF
PRINCIPAL ZONES OF CRYSTALLIZATION

FIGURE 3



BOILING POINT RISE
OF
PRINCIPAL ZONES OF CRYSTALLIZATION AT 175°F

FIGURE 4



CHANGE OF BOILING POINT RISE
WITH TEMPERATURE AT 60° APPARENT PURITY

FIGURE 5

The temperature of the graining charge is also very important. Figure 5[7] shows the change in boiling point rise for a change in temperature at a constant purity of 60. Again it should be noted that as the temperature rises the safe boiling zone increases. At 60 purity, as the boiling liquid temperature increases from 140 to 175° F., the safe boiling zone increases from 8.9 to 10.8° F.

The rate of crystallization also increases as temperature is increased. This is another good reason for graining at a higher temperature.

Erath Sugar Company has standardized on a vacuum of approximately 23 in. of mercury. This is a vapor temperature of 147° and a massecuite temperature of approximately 165 to 175° on the graining charge, depending on the purity used. It should be emphasized that this high temperature is maintained only until the grain has been brought together and normal feed to the pan is started. The vacuum is then gradually raised to 26-27". The "C" strikes are also prepared at a vacuum of 26 to 27". Erath uses a very slow coil pan for graining which requires about 1 hour 15 minutes to boil the charge to graining concentration. Still, with 23" vacuum and a graining charge of 80 purity, the critical period when the grain is being brought together lasts only about 20 minutes. With a 60 purity graining charge and the same vacuum, the critical period lasts about 40-45 minutes. The extra 20-25 minutes required with 60 purity material is not important when it is considered that Erath grains only once every three days. Erath, however, usually grains on syrup at 80 purity. They use the two boiling system and their grain must be relatively high in purity because their "A" molasses runs about 53-54 purity.

The seed may be introduced into the graining charge just as soon as the concentration reaches a point above the saturation line. Ordinarily, this would be at a supersaturation of approximately 1.05 to 1.1. The grain is then brought together and built up in the pan at a supersaturation as high as possible within the metastable zone. It is necessary to avoid the intermediate zone at all times as the existing crystals in the massecuite would provide the appearance of further crystals. Operation in the unsaturated zone should also be avoided because some of the existing crystals would be dissolved.

It is essential that adequate circulation be maintained in the vacuum pan at all times, but it is especially important in the critical period between introduction of the seed and the time when the grain is brought together. In a vacuum pan equipped with a mechanical agitator this is no problem. For those pans not equipped with a mechanical agitator, it may be necessary at times to add movement water. Care should be taken so that the entry of the water into the pan is not concentrated at one point. The water should be distributed throughout the pan as uniformly as possible. This usually means a distributing ring or a star shaped pipe distributor below the calandria. In those vacuum pans equipped with a mechanical agitator, it is possible to control concentration very easily while bringing the grain together simply by turning off the amount of steam into the calandria whenever the concentration gets too high. On those pans not equipped with the mechanical agitator, it is not possible to turn off the steam because then evaporation and circulation in the pan would cease. Since the steam must be left on at all times in order to insure circulation, the concentration of the graining charge must be controlled by the addition of water. Once the grain has been brought together, however, the concentration can be controlled simply by adding more syrup or molasses.

A certain amount of equipment is necessary in order to use the full seeding method of graining. The pan must be equipped with an automatic vacuum controller. It is also essential to have a supersaturation indicator. A mechanical agitator is not absolutely essential but it would certainly be a wise investment.

Most fabrication superintendents at this point would probably ask themselves what is it worth; what results can be expected from all this extra effort? Well, in the first place it is not extra effort. It is the quickest and easiest of all graining methods. The effort involved is much less than for any other graining system. Furthermore, since an excellent control can be obtained over the quantity and size of the "C" sugar crystals, and since they are always much more uniform than with any other method, considerable improvement in factory operations can usually be anticipated. Usually, the "C" massecuites are much easier to purge, the "C" sugar made into a magma and sent back to the pan floor is much higher in purity, and, therefore, the factory recirculates less molasses than before. The final molasses is usually exhausted better and is usually lower in purity. The advantages also extend to the high grade end of the factory. The magma used as a footing for the high grade strikes has a more uniform particle size than with other methods and, of course, the particle size can be controlled to whatever size is desired. The high grade sugar is easier to purge. This is very important if continuous centrifugals are used for purging high grade massecuites.

We suggest that those factory superintendents who are not now using the system study their operations to see whether or not their factory would benefit if the low grade strikes were grained by full seeding.

REFERENCES

1. Eugene C. Gillett, "Low Grade Sugar Crystallization," California and Hawaiian Sugar Refining Corporation, Ltd., Crockett, California, 1948.

2. Alfred L. Webre, "Cane Sugar Handbook" (G. P. Meade, Editor), Eighth Edition, John Wiley & Son, Inc., New York, 1945.

3. Eugene C. Gillett and William Kenda, "Hawaiian Planters' Record," Vol. Llll, January, 1950.

4. "Cane Sugar Handbook," G. P. Meade, Editor, Eighth Edition, John Wiley & Sons, Inc., New York, 1963, Table 24.

5. Alfred L. Webre, "Facts About Sugar," December, 1946.

6. Data for Boiling Point Rise at Saturation Taken from A. L. Holven's Data as Given by Eugene C. Gillett in "Low Grade Sugar Crystallization."

7. IBID

HANDLING SUGAR CANE MUD WITH THE EIMCOBELT FILTER

J. R. Stembridge, Birmingham, Alabama

INTRODUCTION:

In recent years, the mud handling step in the Sugar Cane Processing flowsheet has undergone changes in many sugar houses. One of these changes has consisted of the advent of rotary vacuum filters of the belt and cloth type which utilize chemical treatment of the mud before filtration. In past years, the most common flowsheet for the mud handling step incorporated a perforated screen filter which required recirculation of the filtrate back to the juice clarifiers, due to the open nature of the filter media. This recirculation had a number of disadvantages including possible inversion of the recirculated juice, necessity for more clarifier capacity, and buildup of fine solids in the clarifier causing dirty juice to overflow.

It was impossible to use a tight filter media and obtain a clear filtrate on the rotary type drum filter due to cloth blinding. The term "blinding" refers to the pluggage of the pores in the filter media with the solid particles from the mud or with the waxes which were also present.

In order to attempt to solve the problem of producing a clear juice on a rotary vacuum filter, without encountering media blinding, the rotary belt type filter, such as the EimcoBelt Rotary Vacuum Filter was employed.

This unit consists of a rotary drum filter on which the filter media is a relatively tight filter cloth. The cloth is continuously removed from the filter drum, washed with hot water and returned to the drum during the operation of the filter. By continuous washing, the filter cloth is kept free from blinding and since the media is tighter than would be possible without the cloth wash, a clear filtrate is produced which is sent directly to evaporation.

Filter Sizing and Mud Preparation:

Although the basic operating principle of the belt filter as stated above is not complicated, there are many factors which affect the operation of the unit and make the difference between a smoothly operating piece of equipment and one that gives trouble. SEE FIGURE 1

The first of these factors is a properly sized unit. In general most sugar textbooks refer to filter capacities in terms of tons of cane per day per square foot of filtering area. This is a misleading base for filter sizing since the percent mud on the cane varies from country to country and indeed from sugar house to sugar house. In Louisiana, in dry weather the percent mud on the cane runs around 4% to 5%, but can be 10% or higher after heavy rains. Based on these variations it is generally better to be conservative when sizing the vacuum filter unit. It has been observed that rotary belt filters operating on cane mud with a 1/4" cake generally produce approximately 16 lbs. of wet cake/hr/sq. ft. of filter area. By varying the chemical dosage, it is possible to produce a cake up to 2" thick and thereby obtain very high filtration rates in times of necessity. In general, however, it has been found that the cake thickness of 1/4" gives the best results in terms of cake sucrose because of more efficient cake washing. Therefore, a filtration rate of 16 lbs. of wet cake/hr/sq. ft. of filter area could generally be predicted. The sizing of accessory equipment also affects the rotary belt filter operation to a great extent. Vacuum pumps or steam jet ejectors are usually sized at 0.8 - 1.0 cfm/sq. ft. of filter area at 20" Hg. vacuum. Filtrate pumps are sized at 0.2 GPM/sq. ft. of filter area at the proper head depending on the filter station layout.

Another important factor affecting the filter operation is the operation of the preceding clarifier. It could be stated that the chemical consumption and cake sucrose on the belt filter is inversely proportional to the concentration of the mud being fed to the machine. In other words, the higher the percent solids in the clarifier underflow the less the cost of operating the belt filter and the lower the cake sucrose.

Some recommendations for clarifier operations which will help obtain the best filter performance are: a) Draw mud from the clarifier at the same rate it is being handled at the filter station; b) Maintain the mud level in the clarifier at least as high as the first sample cock; c) Use a diaphragm pump or piston pump to control the mud of flow from the clarifier (Using a valve for this purpose can lead to short circuiting of lighter material through the heavier solids in the bottom of the clarifier); d) Wherever possible it is advisable to feed mud from the Mud Tank to the bagacillo mixer by gravity flow. A centrifugal pump should never be used for this purpose, due to the breakdown in particle size of solids which can occur during pumping at high velocities.

The temperature of the mud to be filtered is another facet of feed preparation which is important to good filter operation. In general, mud temperatures should be as high as possible, since filtration rate is directly proportioned to slurry temperature. Also, in the case of sugar cane mud, waxes are precipitated at 160°F or less and cause more cloth blinding meaning more and hotter belt wash water will be required. Therefore, a minimum retention time conducive to good operation is recommended in the mud handling system prior to filtration.

Bagacillo addition is another very important factor in preparing cane mud for filtration. In the rotary belt filter operation the main function of the bagacillo is to provide cake porosity and therefore better cake washing.

Since Bagacillo is not as great a factor in building cake thickness on a rotary drum belt filter as it is in a rotary drum screen filter, it has been observed that rotary belt filters can operate for extended periods of time without addition of bagacillo. It should be pointed out that under these conditions, however, the chemical consumption at the filter station and the sucrose in the filter cake will be higher than normal operation with bagacillo. At any rate, in time of necessity such as when the mills shut down for extended periods due to mechanical failure or when a clarifier is being liquidated for a planned shutdown, it has proved feasible to run the rotary belt filter without bagacillo.

The percent of bagacillo in wet cake on the rotary belt filter is approximately 6-10%. It is important that this bagacillo be mixed properly if the optimum results are to be obtained. Some mud mixers operate at too high a level so that the incoming bagacillo is deposited on top of the mud and not thoroughly mixed, because of no actual contact with the mixer paddles. Simply lowering the overflow nozzle on the mud mixer tank so that the mud level carried is only slightly higher than the paddles on the mixer shaft will eliminate this problem. Probably the biggest factor in preparing a properly conditioned mud is the addition of flocculating chemicals, such as Separan AP-30 or similar materials. Since these materials are generally solids, they must be dissolved in water before being pumped to the chemical contactor tank for addition to the mud. These flocculants are had to dissolve, and can form sticky lumps and masses if not handled properly. Some pertinent points concerning the addition of the flocculants to water are as follows:

A. Use hot water to dissolve the flocculant.

B. Use a disperser for adding flocculant to the hot water. This device operates as an aspirator which draws the solid material down through a funnel into the water passing through and out at high velocity into the chemical mix tank.

C. Break up all lumps in the solid flocculant before adding to the chemical feed tank.

If these precautions are observed, plugging of strainers, lines and chemical pumps can be prevented, giving an even flow of chemical to the mud for flocculation.

To hold storage tank capacity, and metering pump size to a minimum, generally a more concentrated solution of flocculant is mixed and stored followed by dilution with water after pumping. The normal recommendation is storage of a 0.5% solution and addition of a 0.05% solution to the chemical mix tank meaning addition of water to provide a 10 to 1 dilution is required. This is accomplished by a simple mixing tee arrangement in the chemical feed line where the dilution water is injected into the flocculant solution. Concentration above 0.5% should not be used for direct feed to the mud since a minimum solution volume is required to spread among the mud mass. At times, lower concentration than 0.05% have proven very effective, probably because of better overall contact with the mud due to the increased volume. Normally a metering type pump with a stroke adjustment which is variable during operation is desirable for pumping the flocculating chemical, since mud conditions may vary rather rapidly and, therefore, it becomes necessary to make adjustments in the chemical feed rate while pumping.

Chemical consumption at the filter station varies widely throughout the world, with the average in Louisiana being 0.3 - 0.6 lbs. of flocculant per 100 tons of cane, based on 5% mud on the cane. It has been found that a competent operator can determine when enough flocculant is being added simply by appearance of the mud and after a few days of operation, mud appearance is generally the criterion for adding more or less flocculant.

Many types of chemical mix tanks have been designed to add chemicals to mud and allow proper mixing. The type furnished with the EimcoBelt Rotary Vacuum Unit is called a contactor. This is a vertical tank, generally 18" in diameter fitted with a mixer, mounted behind the vacuum filter tank in a vertical position.

The mud to be treated comes up into the bottom of this unit through the feed line and is mixed with the flocculating agent, which is being pumped into the side of the contactor tank. This mixing occurs in a series of compartments inside the contactor. The mud, having been mixed with chemicals and flocculated then overflows a weir plate at the top of the tank and passes by gravity through troughs to the filter tank. It has been found that troughs are preferred to pipes for this transfer since the mud is in a heavy, flocculated state and tends to plug pipe lines.

Filter Operation:

Now that a properly prepared mud is present at the filter station, several important operational points concerning the filter itself should be considered.

The filter feed rate should be maintained as constant as possible. Any cause for fluccuations in the mud flow should be eliminated if possible. An erratic mud flow causes poor mud flocculation and excessive operator attention, due to the need for increasing and decreasing the flow from the chemical metering pump. The bagacillo balance can also be upset by erratic flow causing very heavy mud with excessive bagacillo and mud with no bagacillo which will be very difficult to wash.

Once the filtration rate is established by controlling the cake thickness and drum speed to keep up with the clarifier underflow, the feed rate should be maintained to prevent excessive overflow of mud from the filter tank to the mud feed tank. Excessive overflow causes extra flocculant consumption, floc deterioration from extra pumping and nonuniform feed consumption and wash efficiency.

As stated previously, a general statement is that the best cake thickness for operating a rotary belt filter is approximately 1/4". This gives the best results in terms of cake washing and allows the cake to be completely discharged.

On the EimcoBelt filter, there is no scraper blade or positive discharge mechasism. The cake discharge is accomplished by a change of direction of the filter cloth as it passes over the discharge roller. With this type discharge, the minimum operable cake thickness is probably 1/8"-1/4". In order to insure that the filter will operate under any set of conditions, regardless of the cake thickness, a sluice header is installed behind the discharge roll to help discharge even very thin cakes.

In order to control the cake thickness at 1/4" or at a rate compatible to the amount of clarifier underflow, there are several things that can be done. The filter drum speed can be increased or decreased to form a thinner or thicker cake. As a rule of thumb, doubling the speed of the filter drum will give approximately 1.4 times the wet cake filtration rate.

It is also possible to vary the flocculant feed rate to change the cake thickness, but it should be emphasized that a minimum cake thickness with 100% discharge is the optimum operating condition and that the amount of flocculant should not be increased to form a heavy cake unless absolutely necessary to handle an extremely heavy mud load.

It is also possible to vary the mud level in the filter tank and increase or decrease the submergence of the filter drum thereby changing the amount of pick up time in relation to drying time. For normal operations a maximum submergence of 25% of the drum circumference is recommended.

Another important factor is the optimizing of the amount of sucrose found in the discharged cake. Experience indicates that with proper cake washing and mud correctly prepared a sucrose valve of from 2 - 4 can be obtained. In general, the amount of sucrose present in the discharged cake increases with an increase in filtration rate or cake thickness.

Poor results in cake sucrose valves result from many things but in general the following things should be checked to help decrease sucrose content.

a. Is the proper amount of bagacillo being used?

b. Is the mud properly flocculated?

c. Is the vacuum low?

d. Is the belt wash efficient and is the belt partially blinded?

e. Is the mud light, with a great proportion of juice, and therefore higher in sucrose?

f. Is the mud temperature low?

g. Are the cake wash nozzles plugged and is the proper amount of wash water reaching the filter cake?

Perhaps the most critical aspect of getting a good operation with the rotary belt filter is maintaining the belt wash water system properly. The minimum temperature of the belt wash water is 180°F. with temperatures of 190°F. and above giving the best results. Also, required is a belt wash pressure of 40 psi with pressure of up to 60 psi giving the best results. The belt wash is applied to the filter cloth through a spray pipe in which a series of high impact nozzles are installed. Normally, three wash pipes are provided, one in front of the filter cloth, another in back of the cloth and a third for helping discharge thin cakes, as mentioned previously. It is important that the nozzles are kept clean to insure a constant wash on the filter cloth. In most cases a set of strainers with monel screens are furnished to strain the cloth wash water before it enters the cloth wash system.

It has been found that during startup the maximum amount of trash is found in the wash water line and a careful check is required during the first few days of filter operation. After this, normal checks of the strainers and nozzles should be sufficient.

Although hot water is available in many mills from direct sources, it is generally recommended that a water tank with a heating system be installed to insure a constant supply of hot water, regardless of whether the rest of the mill is in operation or not. The necessity for water at 180° F. and 40 psi as minimum figures cannot be over-emphasized. At conditions lower than these, waxes from the mud will not be melted and will cause almost immediate blinding of the cloth.

Since the cloth wash water from the rotary belt unit is collected separately in a wash trough arrangement, there is no dilution of the mud in the filter tank because of this water. The only dilution is caused by the cake wash water and this does not cause any significant reduction in brix.

On the rotary belt filter, only the front cloth wash header is normally used. In times of light mud or other difficulty in filtration the wash header behind the cloth may also be used. It is also a good idea to use the header behind the cloth if the water temperature and pressure drop below the specified minimums.

The cloth used on the EimcoBelt filter is a tightly woven multifilament polypropylene filter media. It has a porosity of 30-35 cfm/sq. ft. at 1/2" water pressure. The ends of the cloth are joined by a stainless steel clipper arrangement. The clipper is sealed to prevent solids leakage by the use of a covering flap of cloth which is held in place with a nylon zipper.

Cloth life generally averages two crops. It should be pointed out that the advangage of having no scraper contact with the filter media makes long life possible.

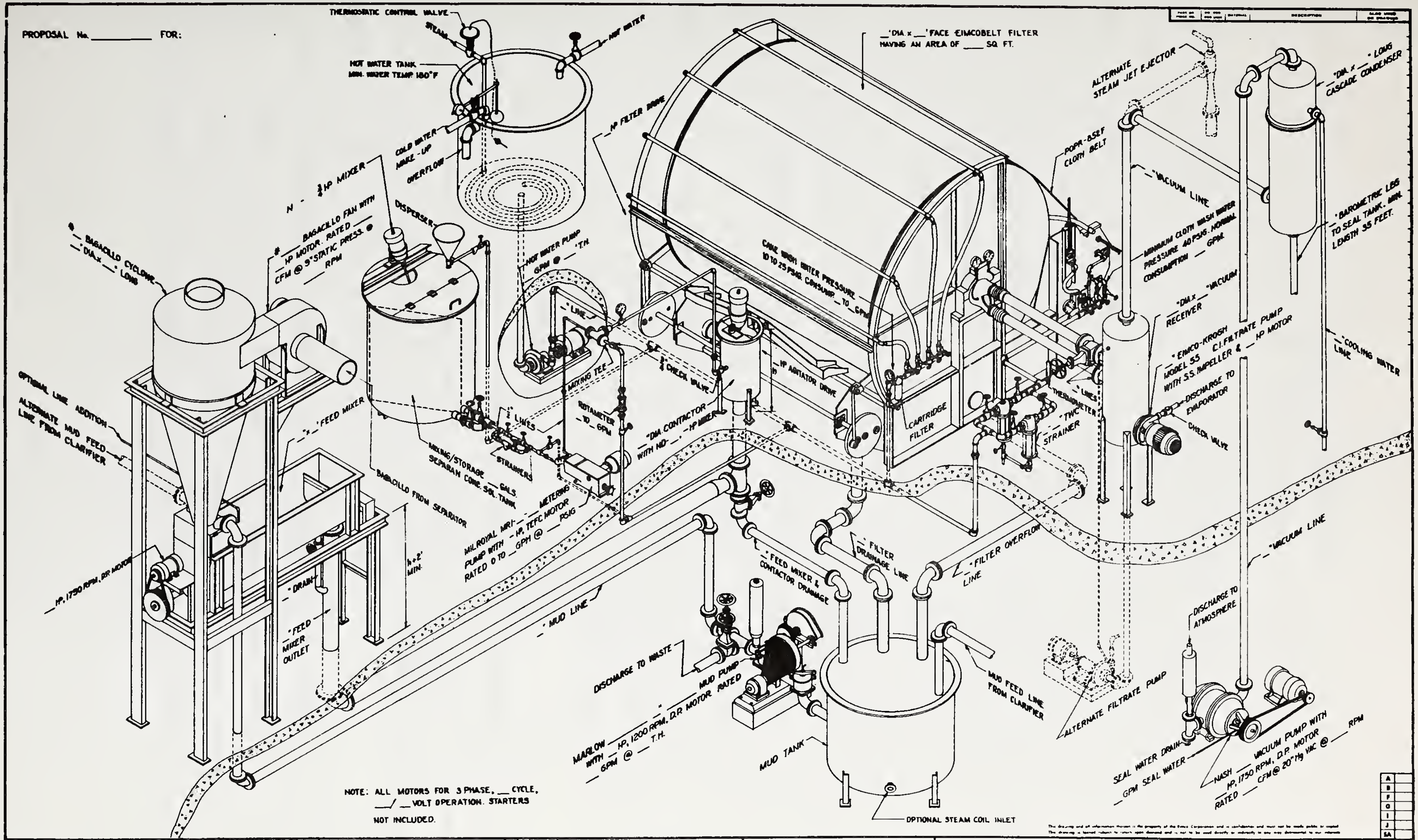
In practically all of the sugar houses in Louisiana in which EimcoBelt Filters have been installed, the juice from the tilter has been acceptable for sending directly to the evaporators and is generally comparable in clarity to clarifier overflow.

SUMMARY

In order to provide direct clarification of cane mud at the filter station without recirculation of juice to the clarifiers, Louisiana sugar factories have been installing rotary filters of the belt type.

In order to insure proper operation of these units, it is necessary that the filter be properly sized and that the mud be properly prepared before filtration. If the above is accomplished, then operation of the filter within a reasonable set of guidelines will provide the sought after goal of a clear juice from the filter station which will not require recirculation.

PROPOSAL No. __________ FOR:


THERMOSTATIC CONTROL VALVE
STEAM
HOT WATER
HOT WATER TANK
MIN. WATER TEMP 180°F
COLD WATER MAKE-UP
OVERFLOW
__HP FILTER DRIVE
N - ¾HP MIXER
DISPERSER
# __ BAGACILLO FAN WITH __HP MOTOR. RATED __ CFM @ 9" STATIC PRESS. @ __ RPM
# __ BAGACILLO CYCLONE __'DIA.x__' LONG
HOT WATER PUMP __GPM @ __'T.H.
__" LINE
MIXING TEE
ROTAMETER __TO__ GPM
¾" CHECK VALVE
__"DIA. CONTACTOR WITH NO-__, __HP MIXER
__HP AGITATOR DRIVE
OPTIONAL LINE ADDITION
ALTERNATE MUD FEED LINE FROM CLARIFIER
__"x__' FEED MIXER
½" LINES
STRAINERS
MIXING/STORAGE __ GALS. SEPARAN CONC. SOL. TANK
BAGACILLO FROM SEPARATOR
MILROYAL MRI-__-__ METERING PUMP WITH __HP, TEFC MOTOR RATED 0 TO __GPH @ __PSIG
__HP, 1750 RPM, D.P. MOTOR
h+2' MIN.
__" DRAIN
__" FEED MIXER OUTLET
__" MUD LINE
DISCHARGE TO WASTE
MARLOW __"__ MUD PUMP WITH __HP, 1200 RPM, D.P. MOTOR RATED __GPM @ __T.H.
__'DIA.x__'FACE EIMCOBELT FILTER HAVING AN AREA OF ____ SQ. FT.
CANE WASH WATER PRESSURE 10 TO 25 PSIG. CONSUMP. __TO__GPM
POPR-852F CLOTH BELT
ALTERNATE STEAM JET EJECTOR
__"DIA x __" LONG CASCADE CONDENSER
__" VACUUM LINE
MINIMUM CLOTH WASH WATER PRESSURE 40 PSIG. NORMAL CONSUMPTION __ GPM
__"BAROMETRIC LEG TO SEAL TANK. MIN. LENGTH 35 FEET.
__"DIA.x__" VACUUM RECEIVER
__" EIMCO-KROGH MODEL 55 C.I. FILTRATE PUMP WITH S.S. IMPELLER & __HP MOTOR
DISCHARGE TO EVAPORATOR
CHECK VALVE
__" COOLING WATER LINE
CARTRIDGE FILTER
THERMOMETER
__" LINES
__" TWC STRAINER
__" FEED MIXER & CONTACTOR DRAINAGE
__" FILTER DRAINAGE LINE
__" FILTER OVERFLOW LINE
__" VACUUM LINE
MUD FEED LINE FROM CLARIFIER
MUD TANK
OPTIONAL STEAM COIL INLET
ALTERNATE FILTRATE PUMP
DISCHARGE TO ATMOSPHERE
SEAL WATER DRAIN
__GPM SEAL WATER
NASH __ VACUUM PUMP WITH __HP, 1750 RPM, D.P. MOTOR RATED __CFM @ 20" Hg VAC @ ____ RPM

NOTE: ALL MOTORS FOR 3 PHASE, __ CYCLE, __/__ VOLT OPERATION. STARTERS NOT INCLUDED.

HOLD FRACTIONAL MACHINED DIMENSIONS TO ±1/64"		MATERIAL	
SCALE NONE	DATE	**THE EIMCO CORPORATION**	EIMCO CANE MUD FILTER STATION USING EIMCOBELT FILTER WITH CHEMICAL TREATMENT
DRAWN BY M.L.FABRE	E-8-FD	ENGINEERING DEPARTMENT SALT LAKE CITY, UTAH	
CHECKED BY			
APPROVED BY			

FILE

NO. REQ'D PER MACHINE

DRAWING, PART & PATT

005Z-260D

SUCHEM AUTO DIFFUSER

Phillippe P. Strich, Ponce Puerto Rico

When the Suchem objective was set two and a half years ago in Puerto Rico, to design and produce a practical and economical cane Diffuser for the Sugar Industry, we knew from past design experience it would take a few years before completing the development and its merit recognized. In Louisiana the first operating diffuser is a Suchem Diffuser and this happened sooner than expected. The short time in which this has been accomplished speaks highly for the user, the licensed manufacturer, and the equipment simplicity.

On June 1, 1968, Louisa Sugar Coop. agreed with Superior Fabricators to install a diffuser on a guaranteed performance basis and six months later, in the early part of November, was able to start processing cane. Past record of diffuser installation is, for a combined delivery-erection, not less than 12-18 months. Suchem experience was based on the same size unit, a 40 ft. diameter diffuser rated at 3000 Short Tons, which was run in Puerto Rico with mostly cane harvested by hand, cane which was washed prior to crushing. In Puerto Rico we had also the flexibility to use a shredder for comparative results.

At Louisa, we were expecting lower extraction, as we had only a standard knife preparation, and we had also to make an allowance for differences in fiber content. The main unknown factor to us was, however, the mud and foreign matter in the cane, its effect on percolation, and bagasse burning.

From these anticipated problems, only the percolation changes proved to be a handicap at first, and kept us from running steadily at the beginning. We had to make an adjustment for generally lower percolation rate than Puerto Rico for the same preparation and we added in Louisiana an overflow system to take care of occasional lack of percolation. These occurrences were very difficult to foresee, generally when the yard was being cleaned, or when there was an unusual percentage of fine.

For those of you not familiar yet with the Autodiffuser, here is a slide showing how it operates. (Brief description.)

The overflow system which was introduced at Louisa, and which makes the Diffuser very suitable for any kind of cane condition, is installed in each compartment. Juice which accidentally does not go through the bed, falls in the stationary tank below and the liquid progression in the opposite direction to the fiber rotation is not affected by the cane conditions.

The flow sheet of the Diffuser at Louisa was identical to the type PM diffuser shown on the next slide, where 60% of the juice is extracted. Two mills in succession were used to dewater the bagasse after the diffuser. (Slides of general view in Puerto Rico and Louisiana.)

During the past season we processed through the Diffuser more than 40,000 Tons of cane and the results until December 30, 1968 are tabulated on the next slide.

You will notice an average difference of 1.5 polarization in bagasse between milling and diffusing. Practically no difference in bagasse moisture when using the tandem alone and the combined diffuser and dewatering mill. Finally with a Diffuser as expected the imbibition was increased nearly to 26%.

Following slides show the calculation for the increase in extraction and the extra raw sugar recovered per ton of cane. We first calculated the sucrose difference between normal juice in the conventional method and with the diffuser. We made certain there was no possible loss of sugar in the diffuser by checking the purity difference between the crushed juice and normal juice, in either case.

Subtracting the sucrose loss with the press water, the increase in pol extraction was 6.06, and 10 lbs. of raw sugar at 96 pol was recovered per ton of cane.

We have not at Louisa Sugar Coop. reached a Pol extraction of 96-97 as can be hoped for with a diffuser working in ideal conditions. The main reason is cane preparation. Because we kept a standard preparation with two sets of knives, with a spacing from the cane carrier for the last setting of up to 1 1/2 inches, and a routine maintenance of one knife change toward the middle of the crop, we did not expect to reach Pol extraction past 95, but we did.

We are asked many times, what is the ideal preparation for the Autodiffuser? We made tests in Puerto Rico at Central Cortada showing that you can reduce by half a point the bagasse polarization (almost two points in extraction) by using a shredder at high speed with the Suchem Diffuser. The question is how far and how much should the preparation be carried out. Our answer is: it is only an economical factor taking in consideration the additional horse power, maintenance and investment. The Autodiffuser justified itself within two to three years in the Louisiana conditions. It is also flexible, can give this result without special preparation, and can handle dirty cane.

There was no disturbance by using the diffuser in the remaining of the factory process.

We were expecting the bagasse to be more difficult to burn with the diffuser as we have normally more dirt staying in the cane; but on the contrary, one of the immediate noticeable advantages of the diffuser was to be able to burn more bagasse. We attribute this fact to bagasse temperature and fluffiness, since the moisture was identical between bagasse from straight milling and bagasse from milling and diffuser combined.

There was no report of color variation in juice, nor difference in boiling with the diffuser. In the premilling type diffuser, 60-65% of the juice is extracted from the cane and follows its traditional course. Also in a diffuser where the cane is not disintegrated, you reduce the juice retention time to its minimum for the maximum effect.

Diffusers have been on the market for many years now. Our contribution with the help of Superior Fabricators and Louisa Sugar Coop. has been to show the Louisiana Sugar Industry they have now with the Autodiffuser a practical and economical tool. From all the methods tried to improve extraction, Suchem gives you the fastest return and the less horsepower requirement.

LOUISA INCREASE RAW SUGAR PER TON OF CANE AND EXTRACTION WITH AUTO DIFFUSER

SUCROSE RECOVERY IN JUICE PER TON OF CANE

Conventional Method:

$$1 \times 2000 \times \frac{15.95}{100} \left(\frac{10.02}{15.95} - \frac{3.65}{44.50}\right) = 174 \text{ Lbs.}$$

By Diffuser:

$$1 \times 2000 \times \frac{15.95}{100} \left(\frac{10.02}{15.95} - \frac{2.15}{44.5}\right) = 187 \text{ Lbs.}$$

Sucrose Difference: = 13 Lbs.

CHECK ON POSSIBLE LOSS OF SUGAR IN DIFFUSER

	Purity of Crushed Juice	Normal Juice	Purity Difference
1st Week	78.89	75.49	3.40
2nd "	78.98	75.82	3.16
3rd "	78.94	76.40	2.92
4th "	80.06	77.14	2.92
5th "	80.51	77.45	3.06
6th "	80.58	77.58	3.00
7th "	81.27	78.09	3.18
8th "	81.09	77.98	3.11
9th "	79.36	76.36	3.00
		Average:	3.06
Dec 22 With Diffuser	77.35	74.39	2.94
Dec 27 With Almost No Diffuser	79.46	76.16	3.30
Dec 28 With Complete Diffuser	78.73	75.69	3.14

CALCULATION OF SUGAR LOSS WITH PRESS WATER MUD

Based on Brix and Pol and 8% Initial Imbibition Water Taken by Mud Pump

1.12 Lbs. per Ton of Cane

INCREASE IN POL EXTRACTION

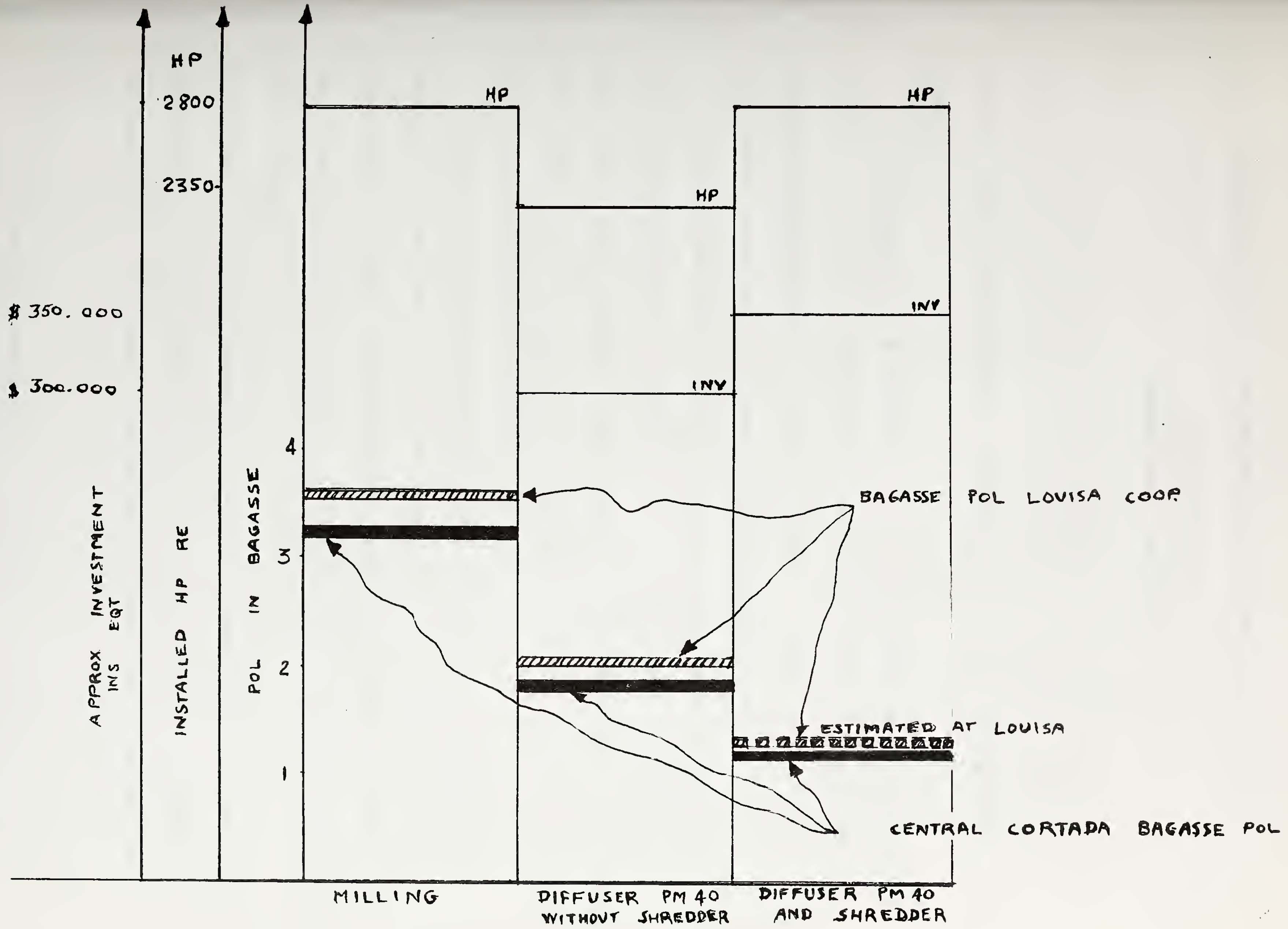
$$\frac{13 - 1.12}{174} \times 89 = \underline{6.06}$$

THE EXTRA RAW SUGAR 96 POL PER TON OF CANE

$$\frac{11.8 \times 0.85}{0.96}$$ (Recovery of Retention Factor) = 10 Lbs.

DIFFUSION DAILY OPERATING RESULTS LOUISA SUGAR COOP

Date	Tons of Cane	Pol in Bagasse with Diffusion	Bagasse Moisture Daily	Fiber in Cane Calculated	Pol in Cane	Imbibition Daily
Nov 13	1870	2.64	48.10	15.81	10.146	24.12
Nov 14	1376	2.42	49.5	16.08	10.214	24.12
Nov 18	2552	1.84	48.90	15.99	9.904	23.53
Nov 19				16.59	10.1	21.80
Nov 20	1594	1.85	49.73	16.21	10.149	26.22
Nov 23	885	2.11	50.40	16.12	10.334	26.24
Nov 27	1444	1.99	53.50	15.20	10.036	28.06
Nov 30	1530	1.98	50.10	16.18	9.66	23.56
Dec 1	970		50.15	15.87	9.82	21.40
Dec 2	200		50.08	15.92	9.88	19.92
Dec 3			49.30	17.25	9.685	21.70
Dec 4	198		47.88	18.47	10.15	29.16
Dec 6	2118	1.64	51.25	17.11	9.796	29.16
Dec 7			51.15	16.49	10.2	25.81
Dec 8	2250	2.55	51.50	15.81	10.005	21.03
Dec 9			52.25	15.44	10.334	28.39
Dec 10			52.83	14.53	10.475	23.96
Dec 11	1743	2.25	53.25	14.50	10.53	26.45
Dec 12			52.03	15.05	10.32	33.85
Dec 13	272	2.05	51.83	15.75	10.15	34.77
Dec 16	1142	1.98	51.13	15.89	10.17	30.61
Dec 22	2157	2.69	53.20	14.67	10.10	27.16
Dec 23	1370	2.11	52.60	14.64	9.74	22.08
Dec 24	1055	2.03	52.65	14.03	9.76	22.74
Dec 25	1500	2.45	51.00	15.19	9.84	22.62
Dec 26	554		49.58	16.88	9.87	24.54
Dec 27	840	1.98	50.88	17.99	9.44	26.96
Dec 28	2117	2.26	51.93	17.42	9.38	27.88
Dec 29	1835	2.05	52.13	17.38	8.69	31.33
Dec 30	1977	2.16	50.32	18.17	8.98	27.53
Average from Above		2.15	51.00			25.80
Average to Date with Milling and Diffuser			51.06			22.97
Average to Date with Milling only		3.65				
Difference Minus		1.50				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SUCHEM INC.

CURRENT STATUS OF SUGARCANE BORER CONTROL IN LOUISIANA[1]

S. D. Hensley
Entomology Dept., L.S.U.
Baton Rouge, Louisiana

The sugarcane borer Diatraea saccharalis (F.) is the most serious and destructive insect attacking sugarcane in Louisiana. From 1937 to 1959, yield losses ascribed to damage by this pest averaged 13% annually.

D. saccharalis is a crambid species whose larvae tunnel gramineous plants. Its principle cultivated hosts in Louisiana are sugarcane (Saccharum officinarum L.), corn (Zea mays. L.), rice (Oryza sativa L.) and several varieties of sorghum (Sorghum vulgare Pers.),

The sugarcane borer injures sugarcane primarily by retarding growth and stunting plants, thus causing loss in stalk weight (tonnage). It also affects juice quality, causes stalks to break and lodge, and destroys some vegetative buds (eyes) of seed pieces, but these are of lesser importance than its effect on tonnage.

Eggs of this pest are deposited on leaves of the sugarcane plant and the young larvae feed in the plant whorls and leaf sheaths until half grown (about 10 days) before tunneling into stalks where they complete development and pupate. The life cycle from egg to adult is completed in 30 to 40 days.

There are 3 to 4 generations of the sugarcane borer each year in Louisiana. It overwinters as 5th and 7th instar larvae in dispause in old cane stubs and pieces of stalks left in the field at harvest time.

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[1] This paper is a resume of an invitational address delivered by Dr. S. D. Hensley, Department of Entomology, Louisiana State University, to the International Seminar on Integrated Pest Control, New Delhi, India, January 20, 1969.

Winter temperatures below 20°F often cause more than 80% mortality to overwintering sugarcane borer populations. Dry weather, especially during the spring when first generation larvae are attacking small cane plants may cause more than 50% mortality. The biology of the sugarcane borer appears to be well synchronized to that of its host plant, especially in respect to climatic conditions. Weather conditions favorable to cane growth, (warm temperature and adequate rainfall) invariably result in increases in sugarcane borer populations.

Prior to 1958, attempts to control the sugarcane borer involved: 1) use of cultural practices (19, 20, 21); 2) introduction of exotic parasites (3, 4, 22); 3) release of laboratory reared egg parasites of the genus *Trichogramma* (18) and 4) use of the insecticides ryania and cryolite (6, 8, 21) which were later shown to have provided less than 50% control (25). These practices were not sufficiently effective in Louisiana to prevent the sugarcane borer from causing severe crop losses (29).

The present control program which has been developed within the last decade and has gained wide acceptance by growers is based on the following principles of plant pest population management: 1) Development of adequate survey techniques whereby growers or professional entomologists can accurately determine density of larval infestations in the field; 2) establishment of an economic injury treshold in order to more accurately determine need for insecticide applications to prevent crop losses; 3) utilization of highly effective insecticides for treating only those infestations found to be higher than the economic injury threshold; and 4) emphasis on growers utilizing resistant varieties and certain cultural practices as means of reducing insecticide use.

Survey Methods

Prior to 1958, ryania or cryolite was recommended for control of first, second and third generation infestations and the survey method used to determine need for insecticide applications was based on counting leaf-feeding signs or borer-killed plants in the spring at the time of first generation attack. Once the required number of these superficial signs were attained in a specific field., the grower was advised to apply insecticide on a fixed weekly treating schedule for the remainder of the crop season (7). These procedures could and often did result in growers applying 8 to 12 applications of ryania or cryolite at a cost of $24 to $30 per acre from June through August for relatively poor control of two or three generations.

More recent data show that stand reductions by first generation borers are not of sufficient magnitude to cause reductions in sugar yields and that there is little benefit to be derived from using insecticides to control first generation infestations to reduce population density of subsequent generations, especially when individual fields of 200 acres or less are treated (15). Thus control of first generation infestations with insecticides is no longer recommended.

The survey method now used requires the grower or a professional entomologist to make weekly examinations of infestation conditions in the crop from the latter part of June until the end of August, which is the critical period of time when larvae of the second and third generations are injuring millable joints that are later harvested for yield (24). Infestation counts are made at 6 locations in a diagonal line across each 40 acres of the crop by randomly selecting and examining 50 stalks at each location. The number of stalks infested with small larvae in leafsheaths is recorded and treatment is recommended when 5% of the stalks are infested. The survey is continued throughout the season and re-treatment is recommended only when 5% reinfestation of the crop occurs (2).

This survey method provides several advantages over that formerly used. It permits continuous management of the pest population and precludes fixed application schedules. It permits quick detection of poor control due to bad timing, faulty aerial application, ineffective insecticide formulations or applications rendered ineffective by heavy rainfall. It allows consideration to be given to differences in susceptibility of sugarcane varieties to sugarcane borer attack. It also allows consideration of the effects of beneficial insects and/or weather on borer populations, since the infestation counts are based on the presence of living larvae in plants and not on superficial signs of larvae that may have been subsequently destroyed by predators or other mortality factors.

Utilization of this survey method has led to better surveillance and protection of more crop acreage, yet overall insecticide usage has been reduced due to discontinuance of fixed application schedules. Approximately 100,000 of 270,000 acres of sugarcane were surveyed in 1968 by professional entomologists at a cost to growers of $1.00 to $1.50 per acre. One entomologist can adequately survey about 7,500 acres per week. Professional entomologists are utilized on the larger farms and infestations on farms of 200 acres or less are usually surveyed by the owners.

Treatment Treshold

The point at which density of infestation by a crop pest begins to affect yield is difficult to determine. Consideration must necessarily be given to quality, quantity, and economic value of the crop and the efficacy and cost of control procedures to growers. The 5% population level now used as the treatment treshold for the sugarcane borer in Louisiana is based on the premise that uncontrolled infestations at that level will result in more than 10% joints bored during a crop season accompanied by yield reductions of 1.5 tons of cane per acre currently valued at $16.50 ($11.00 per ton). This amount is slightly in excess of $13.00, the sum a grower may need to pay for a maximum seasonal insecticide program (3 applications for control of heavy infestations) and includes cost of field survey service, insecticides and their application. The 5% treatment treshold was derived from correlation of yield losses and infestation levels in large-plot field experiments.

Cultural Practices

A steadily diminishing labor force plus increasing cost of available labor has had a marked influence on cultural control of the sugarcane borer in Louisiana. Many practices formerly considered beneficial (6) are no longer recommended to growers (2). Those practices that have been discontinued include: 1) destroying infested plant residues (trash) by burning and/or removing it from fields, 2) cutting and burning small infested plants in the spring when sugarcane borer populations are low and 3) shaving heavily infested fields in the spring.

Only 3 of the 10 cultural practices recommended to growers in 1958 are still in use. These are: 1) plant non-infested cane to improve plant stands, 2) plow out old stubble fields as quickly as possible after harvest to destroy overwintering larval populations and 3) plant corn as far away as possible from cane to reduce late summer moth migration from corn to cane. None of these require extensive use of farm labor.

Insecticides

Two insecticides, the chlorinated hydrocarbon endrin and the organic phosphate azinphosmethyl (guthion), have proven most effective of more than 100 compounds screened for sugarcane borer control within the last decade (14, 17, 25). Two percent endrin granules applied at rates of .25-.30 lb. active ingredient per acre and at 2-3 week intervals between applications was used almost exclusively from 1958 to 1963 when resistance to it and other chlorinated hydrocarbon insecticides developed in sugarcane borer populations (31). Azinphosmethyl, applied as 5% granules at a rate of .75 lb. active ingredient per acre or as a spray at a rate of .75 lb. active ingredient in 2 gallons of water per acre has replaced endrin and is now the only insecticide recommended for general use against borer infestations in Louisiana. Azinphosmethyl formulations are also applied at 2-3 week intervals between applications.

A summary of results obtained from airplane-treated large-plot field tests in which endrin or azinphosmethyl were applied at recommended application rates and treatment intervals is shown in table 1. Reductions in bored joints of more than 85% and yield increases ranging from 5.00 to 8.65 tons of cane per acre were obtained following 3 to 4 applications of these formulations for control of second and third generation infestations. More recently, effective control of the sugarcane borer in experimental plots has been obtained with the carbamate insecticide carbofuran (Furadan) and the organic phosphate azodrin when applied at rates of .50 and .75 lb. active ingredient per acre, respectively. Azodrin is the only insecticide tested for sugarcane borer control in Louisiana that has shown a high level of plant systemic activity by killing large larvae which have tunneled into stalks (14).

Comparison of spray and granular formulations of azinphosmethyl showed little difference in effectiveness between formulations (5, 10). However, granular formulations appear to provide more residual control especially when applied during periods of heavy rainfall. Ultra low-volume concentrates of azinphosmethyl and azodrin have provided control comparable to that obtained with conventional spray and granular formulations (11) but this method of application has not yet been recommended for use on sugarcane in Louisiana.

More than 95% of the insecticide used to control the sugarcane borer in Louisiana is applied from airplanes. Muddy fields resulting from frequent rains prevent extensive use of ground application equipment. Poor control has been experienced recently on some sugarcane acreage when pilots attempted to fly excessively wide swathwidths and failed to obtain crop coverage. Comparison of different swathwidths for three types of aircraft commonly used in Louisiana for aerial services on sugarcane show that wide swaths, those from 6 to 30 feet wider than the wingspan of the aircraft, resulted in extremely erratic distribution of insecticides regardless of the type or size of aircraft flown or insecticide formulation applied.

For this reason, swathwidths now recommended to sugarcane growers in Louisiana are limited to widths not in excess of 6 feet wider than the wingspans of aircraft. Granular formulations are applied at plane heights of 30-50 feet and spray formulations are applied as close to the top of the crop as safety to pilots will permit.

Good insecticidal control of the sugarcane borer has been obtained within the last decade primarily because the insecticide endrin and later its replacement azinphosmethyl, were: 1) sufficiently effective to destroy 90% or more of the larval population of the sugarcane borer when timed and applied properly and 2) they possessed sufficient residual activity to permit 2 to 3 week intervals between applications. Furthermore, these insecticides have been economical to growers. Based on the value of a ton of sugarcane in Louisiana ($11.00), growers have realized $50.00 to $90.00 per acre in yield increases by following a control program that required maximum expenditures of less than $10.00 per acre for endrin and $15.00 per acre for azinphosmethyl.

Resistant Varieties

A summary of yield response of commercial sugarcane varieties to sugarcane borer attack is shown in table 2. Data on yields and percentages of joints bored in insecticide-treated and untreated plots of 5 varieties planted in 14 experiments were accumulated from 1959 to 1965 (13, 26). These varieties, NCO 310, C.P. 36-105, C.P. 5268, (resistant) and C.P. 48-103 and 44-101 (susceptible) comprised more than 90% of the total acreage of sugarcane in production during this period.

All 5 varieties were replicated 4 times in each experiment and individual plots were 1/70 acre in area (3 rows x 35 ft.). Two plots of each variety in each experiment were treated with 3 or 4 tri-weekly insecticide applications to control second and third generation infestations and the other two served as untreated controls. Endrin granules were applied to treated plots until 1963 and azinphosmethyl granules thereafter.

Effective control with insecticides was attained in all 5 varieties (table 2). Differences in percent control among varieties were not statistically significant and ranged from 88% for C.P. 44-101 to 91% for NCO 310. However, differences in percent yield loss among varieties were significant and ranged from a low of 14.6% for NCO 310 to a high of 28.6% for C.P. 44-101.

Sugarcane borer resistant varieties have already had a marked impact on the amount of insecticide expended for sugarcane borer control and will continue to influence future control programs. Surveys of grower use of insecticides during the past 3 years, especially on those farms where professional entomologists have been employed to survey infestations and recommend treatment, show an average of 1.3 applications per season were made for control of infestations on the resistant variety NCO 310 compared to 2.9 applications for the susceptible variety C.P. 44-101. Thus growers producing variety NCO 310 have reduced insecticide usage more than 50%.

Very little is known about host plant mechanisms associated with resistance or susceptibility of Louisiana sugarcane varieties to sugarcane borer attack. Many "varietal characters" have been associated with resistance (27). However, no data are presented to support these conclusions. Regardless of the current lack of knowledge about resistance mechanisms (host preference, antibiosis and tolerance), it is evident that low levels of resistance that are meaningful in terms of yield increases are already present in some commercial varieties. These varieties should be utilized more often in variety breeding programs.

Potential Methods of Control

Discovery of a highly potent sex pheromone produced by the female of the sugarcane borer (30) has led to considerable research effort towards developing a control measure based on the principle of annihilatin male moths in naturally occurring field populations. A synthetic diet adequate for rearing large numbers of larvae has been developed (12) and to date, more than 800,000 larvae have been reared for use in studies of the identity of the pheromone and for evaluation of its effectiveness in the field. Small-plot experiments in which virgin female moths confined in "sticky" traps were used to lure and eliminate males have shown that significant reduction in populations and damage were achieved when traps, each containing one virgin female, were maintained continuously in plots at the rate of 400-800 per acre (9). Studies on the chemical composition of the pheromone have been in progress for 4 years but it has not yet been identified.

Biological Control

Attempts to utilize several exotic parasites from South America as biological control agents of the sugarcane borer in Louisiana have not been successful. From 1915 to 1957, three tachinid species, _Lixophaga diatraeae_ (Towns.), _Metagonistylum minense_ (Towns.), _Paratheresia claripalpis_ (v.d.W.) and one braconid species (_Agathis stigmaterus_ Cress.) were released repeatedly in Louisiana sugarcane fields (3, 4, 22). Only one of these (*L.diatraeae*) is known to have established and it parasitizes less than 4% of the sugarcane borer population in the field. Reasons set forth for failure of these parasites to establish are: 1) that winter temperatures may be below their survival limits and 2) that there is not sufficient host populations available in the winter to maintain these parasites from one season of cane growth to the next (4).

Population enhancement programs involving use of egg parasites of the genus *Trichogramma* have not provided control of the sugarcane borer in Louisiana. For many years it was believed that release of laboratory-reared *Trichogramma* in the spring at a rate of 5,000 to 10,000 per acre and when sugarcane borer populations were at a low ebb, would provide sufficient parasitization to achieve and sustain economic control during the critical period of sugarcane borer injury to the crop (18). However, this practice failed to provide control when releases were made at rates as high as 43,000 per acre (1, 23).

Recent studies concerning parasitization by *Trichogramma* of two Lepidopterous borers attacking rice (*D. saccharalis* and *Chilo plejadellus* Zincken) show that high levels of parasitization (90%+) were observed on this crop, whenever field populations of *Trichogramma* reached levels of 300,000 to 800,000 per acre.

More recently, predatory arthropods have been found to be most beneficial of all biological control agents present in Louisiana sugarcane fields (16, 38). A list of those species observed preying on the sugarcane borer and the life stages preyed on is presented in table 3. This complex of Arthropods are known to provide partial control of the sugarcane borer.

During 1958 and 1959 when attempts were made to eradicate the imported fire ant, Solenopsis saevissima richteri Forel from the southern United States, large acreages of sugarcane were treated with a broadcast application of 10% heptachlor granules at a rate of 2.00 lbs. active ingredient per acre. This program virtually eliminated all arthropods that prey on the sugarcane borer from treated fields and as a result sugarcane borer injury was significantly higher than in untreated fields for a period of more than 1 year following application of heptachlor (tables 4 and 5).

Two insecticides applied for control of the sugarcane borer (cryolite and carbaryl) have resulted in late season increase in populations of the yellow sugarcane aphid, Sipha flava (Forbes), by reducing populations of coccinellids. However, these increases in aphid populations apparently occur too near cane harvest to affect sugar yields. Endrin and azinphosmethyl have not caused rises in aphid populations.

Use of endrin granules has caused damage to aquatic organisms, especially fish, when it was washed by rains into streams adjacent to sugarcane farms. However, replacing endrin with azinphosmethyl has alleviated most of this problem. Azinphosmethyl is also less detrimental than endrin to predator populations (28).

Discussion

The somewhat "primitive" system of pest population management now being practiced in Louisiana for control of the sugarcane borer on sugarcane takes full advantage of the suppressive effects of a large complex of arthropod predators, varietal resistance and adverse weather conditions. However, it relies on the judicial use of synthetic organic insecticides for control of infestations which overwhelm these natural control agents. It is anticipated that reliance will continue to be placed on insecticides used in this manner for the foreseeable future.

Development of resistance to insecticides in sugarcane borer populations has been and will continue to be a problem. Endrin's effectiveness was negated by development of resistant populations after approximately 6 years of large-scale usage. Until now, levels of resistance that would prevent economic control with azinphosmethyl have not been detected in sugarcane borer populations in Louisiana. However, should it occur, the carbamate, carbofuran, which is providing effective control in experimental plots may serve as a replacement.

Damage by insecticides to beneficial insects and aquatic organisms, especially fish, was a problem from 1959 to 1961, when large quantities of endrin granules were applied for sugarcane borer control on fixed application schedules. However, there have been fewer problems with azinphosmethyl, primarily because of discontinuance of fixed application schedules, use of spray formulations and also because of less detrimental effects by azinphosmethyl on non-target organisms.

Low to moderate levels of varietal resistance to sugarcane borer attack, which received little attention from research personnel or growers in the past, are now being recognized as a worthwhile and inexpensive means of increasing sugar yields and reducing insecticide usage. There is much yet to be learned about host preference, antibiosis and tolerance of Louisiana sugarcane varieties to sugarcane borer attack. However, lack of knowledge of these or other host-plant resistance mechanisms should not preclude extensive screening for sources of resistance and sound variety breeding programs, designed to incorporate resistance to the sugarcane borer into commercil varieties.

Some cultural measures of small or dubious value for control of the sugarcane borer have been discontinued due to increased costs of labor required for their implementation.

Use of biological control agents, especially release of exotic parasites and Trichogramma enhancement programs, did not provide any appreciable degree of control of the sugarcane borer and were discontinued several years ago. Much research is currently being directed towards evaluating control by native arthropod predators and the effects of different insecticides on their populations.

"Biological upsets" due to injudicious use of insecticides, especially of the magnitude of that caused by heptachlor in the program for eradication of the imported fire ant from the southern United States, have not occurred with insecticides recommended for sugarcane borer control in Louisiana. Efforts will continue towards preventing disasters of this nature.

An alternate control program based on luring and annihilating males from natural sugarcane borer populations with the sugarcane borer female sex pheromone may be feasible in the future. However, it should be emphasized that it and other "new sophisticated" control programs must await future research developments and then must be effective and practical in terms of cost to growers.

The real value of the control program described herein is that it emphasizes pest management practices having the following desirable characteristics: 1) proven effectiveness, 2) economical, 3) easy to implement and to put into operation rapidly, 4) minimum adverse effects on non-target organisms, and 5) minimum pollution of the environment with persisting toxic residues.

Table 1. Effectiveness of endrin and azinphosmethyl for control of the sugarcane borer, South Louisiana 1958-67.

Insecticide Formulation	Application rate (lbs. acting/acre)	% Joints Bored		% Control	Yield Increase (Tons of Cane per Acre)
		Treated	Untreated		
2% endrin[a] granules	.25	5	45	88	8.24
7% azinphosmethyl[b] granules	1.00	5	34	90	5.80
Azinphosmethyl[b] E.C. 2 lbs./gal.	1.00	3	32	91	5.00

[a] Data selected from (25). Figures are averages of 19 replications from 4 large plot experiments in which 3 biweekly applications were applied for control of second and third generation infestations.

[b] Data selected from (17). Figures are averages of 12 replications from 3 large-plot tests in which 3 triweekly applications were made for control of second and third generation infestations.

Table 2. Per cent insecticidal control and per cent yield loss among commercial varieties of sugarcane, South Louisiana, 1959-1965.

Variety	% Control	% Yield Loss	Orthogonal Comparisons (Yield Loss)
NCO 310	91.0	A 14.6	ABC vs DE**
C.P. 36-105	87.4	B 17.6	A vs BC*
C.P. 52-68	88.4	C 18.7	B vs C$^{n.s.}$
C.P. 48-103	86.5	D 25.0	D vs E*
C.P. 44-101	88.0	E 28.6	

Data selected from (13).

n.s. = Non-significant
* = Statistically significant at the 5% level of probability.
** = Statistically significant at the 1% level of probability.

Table 3. Arthropod predators observed preying on the sugarcane borer and life stages preyed on, Napoleonville, Louisiana, June to September, 1966 and 1967.

	Stage or stages preyed on
Hymonoptera (Formicidae)	
Iridomyrmex humilis Mayr.	egg, larva
Pheidole dentata Mayr.	egg, larva
Solenopsis saevissima richteri Forel	egg, larva, pupa
Solenopsis xyloni McCook	egg, larva
Coleoptera (Carabidae)	
Laptotrachelus dorsalis (Fab.)	egg
Chlaenius pusillus Say	egg
Harpalus sp.	larva
Calasoma sp.	larva
Coccinellidae	
Seymnus (*Dicmus*) *terminalus* Say	egg
Hippodamia convergens Guerin-Meneville	egg
Coleomegilla maculata Degeer	egg
Elateridae	
Conoderus vespertinus (Fab.)	egg, larva
C. rudis Brown	egg
Drasterius scutellatus Schffr.	egg
Neuroptera (Chrysopidae)	
Chrysopa sp.	egg
Dermaptera	
Doru aculeatum (Scudder)	egg, larva
Anisolabis annulipes (Lucas)	larva
Labidura riparia (Pallas)	larva
Araneida	
Eperigone tridentata Emerton	egg
Pardosa milvina (Hentz)	egg
Singa variabilis Emerton	egg, larva
Achaearanea index Chamberline and Ivie	egg
Coleosoma acutiventer Keyserling	egg
Paratheridula quadrimaculatus Banks	egg
Clubiona abotti L. Koch	egg, larva
Lycosa helluo Walck.	adult
Habronattus coronatus (Hentz)	egg

Table 4. Injury to sugarcane by the sugarcane borer in heptachlor-treated and untreated fields, South Louisiana, October 1958.

Parish	Number of Comparisons	Average Joints Borer (%)* Heptachlor Treated fields	Average Joints Borer (%)* Heptachlor Untreated Fields
St. Mary	22	65	52
Iberia	10	61	40
Lafayette	8	62	33
	40	63	42

Data selected from (16)

*Based on examination of a single stalk randomly selected from each of 10 stools 3 ft. apart in a single row of sugarcane. Examinations of stalks were made 8 months after application of heptachlor at a rate of 2.00 lbs. active ingredient per acre.

Table 5. Number of plants killed by first generation sugarcane borers in heptachlor treated and untreated fields, South Louisiana, June 1959*

		Average Number of Borer-killed Stalks Per Acre	
		Heptachlor	
Parish	Comparisons	Treated Fields	Untreated Fields
St. Mary	14	2770	561
Iberia	8	1512	300
	22	2312	466

Data selected from (16)

*Based on counting the number of borer-killed stalks on 72 ft. of row (1/100 acre) in each of 4 rows three rows apart in each field. Counts were made 14 months after application of heptachlor at a rate of 2.00 lbs. active ingredient per acre.

Literature Cited

1. Burrel, R. W. and W. J. McCormick. Effect of Trichogramma Releases on Parasitism of Sugarcane Borer Eggs. J. Econ. Entomol. 55, 880-82 (1962)

2. Cancienne, E. A. and S. D. Hensley. How to Control the Sugarcane Borer. Sugar Bull. 44, 268-71 (1966).

3. Charpentier, Leon J., W. J. McCormick, and Ralph Mathes. Biological Control of the Sugarcane Borer in Louisiana. Proc. Intern. Congr. Sugarcane Technol. 10th, 865-69 (1959).

4. Clausen, C.P. Biological Control of Insect Pests in the Continental United States. U. S. Dept. Agr. Tech. Bull. 1149, 151 pp. (1956).

5. Davis, Leland, Francis Bonner, and S. D. Hensley. Residues on Sugarcane Tissue 24 Hours after Application of Azinphosmethyl. J. Econ. Entomol., (In Press) (1969).

6. Dugas, A. L. Recommendations for a Sugarcane Borer Control Program in Louisiana. La. Univ. Agr. Expt. Stat. Bull., 363, 14 pp. (1943).

7. Dugas, A. L. Recommendations for the Chemical Control of the Sugarcane Borer in Louisiana. Sugar Bull.,34, 191-92 (1956).

8. Dugas, A.L. Insect Investigations (mimeographed annual reports to the Contact Committee of the American Sugarcane League). Unpublished 1947-1955.

9. Hensley, S.D. Research on a Sugarcane Borer Sex Attractant. Sugar J. 29, 40-43 (1967).

10. Hensley, S. D. and E. J. Concienne. Comparison of Granular and Spray Formulations of Insecticide for Control of the Sugarcane Borer. Sugar Bull. 45, 26-30 (1966).

11. Hensley, S. D. and Leland F. David. Control of the Sugarcane Borer With Low Volume Concentrates of Insecticides. Sugar Bull., 45, 86-88 (1966).

12. Hensley, S. D. and Abner M. Hammond. Laboratory Techniques for Rearing the Sugarcane Borer on an Artificial Diet. J. Econ. Entomol. 61, 1742-43 (1968).

13. Hensley, S. D. and W. H. Long. Differential Yield Response of Commercial Sugarcane Varieties to Sugarcane Borer Damage. J. Econ. Entomol., (In Press) (1969).

14. Hensley, S. D., E. J. Concienne, W. J. McCormick, and L. J. Charpentier. Azodrin, A New Promising Insecticide for Control of the Sugarcane Borer in Louisiana. Sugar Bull., 45, 110-14 (1967).

15. Hensley, S. D., W. H. Long, E. J. Concienne, and W. J. McCormick. Control of First Generation Sugarcane Borer Populations in Louisiana. J. Econ. Entomol., 56, 407-09 (1963).

16. Hensley, S. D., W. H. Long, L. R. Roddy, W. J. McCormick, and E. J. Concienne. Effects of Insecticides on the Predaceous Arthropod Fauns of Louisiana Sugarcane Fields. J. Econ. Entomol., 54, 146-49. (1961).

17. Hensley, S. D., E. J. Concienne and Graduate Assistants. Summaries on Research of Sugarcane Insects, (Mimeographed Annual Reports to the Contact Committee of the American Sugarcane League, Unpublished) (1965-1968).

18. Hinds, W. E., B. A. Osterberger, and A. L. Dugas. Review of Six Seasons Work in Louisiana in Controlling the Sugarcane Moth Borer by Field Colonizations of its Egg Parasites Trichogramma minutum Riley. La. Univ. Agr. Expt. Sta. Bull., 235, 33 pp. (1933).

19. Holloway, T.E., W. E. Haley, and A. C. Loftin. The Sugarcane Moth Borer in the United States. U. S. Dept. Agr. Tech. Bull., 41, 75 pp. (1928).

20. Ingram, J. W. and K. K. Bynum. The Sugarcane Borer. U. S. Dept. Agr. Farmers Bull., 1884, 17 pp. (1941).

21. Ingram, J. W., E. K. Bynum, and Ralph Mathes. Pests of Sugarcane and Their Control. U. S. Dept. Agr. Circ., 878, 38 pp. (1951).

22. Jaynes, H. A. The parasites of the Sugarcane Borer in Argentina and Peru, and Their Introduction into the United States. U. S. Dept. Agr. Tech. Bull., 363, 27 pp. (1933).

23. Jaynes, H. A. and E. K. Bynum. Experiments with Trichogramma minutum Riley as a Control of the Sugarcane Borer in Louisiana. U. S. Dept. Agr. Tech. Bull., 743, 42 pp. (1941).

24. Long, W. H. and E. J. Concienne. Critical Period for Controlling the Sugarcane Borer in Sugarcane in Louisiana. J. Econ. Entomol. 57, 350-53 (1964).

25. Long, W. H., E. J. Concienne, S. D. Hensley, W. J. McCormick, and L. D. Newsom. Control of the Sugarcane Borer with Insecticides. J. Econ. Entomol., 52, 821-24 (1959).

26. Long, W. H., S. D. Hensley, E. J. Concienne, and T. J. Stafford. A new Method for Rating Sugarcane Varieties for Susceptibility to Sugarcane Borer Attach. Sugar Bull., 39, 175-78 (1961).

27. Mathes, Ralph and L. J. Charpentier. Some Techniques and Observations in Studying Resistance of Sugarcane Varieties to the Sugarcane Borer in Louisiana. Proc. Intern. Congr. Sugarcane Technol. 11th, 594-602 (1962).

28. Negm, Ahmed A. and S. D. Hensley. The Relationship of Arthropod Predators to Crop Damage Inflicted by the Sugarcane Borer. J. Econ. Entomol., 60, 1103-06 (1967).

29. Newsom, L. D. Endrin for Sugarcane Borer Control. A look into the future. Sugar Bull., 37, 214-20 (1959).

30. Perez, Raphael and W. H. Long. Sex Attractant and Mating Behavior of the Sugarcane Borer. J. Econ. Entomol., 57, 688-90 (1964).

31. Yadav, R. P., H. L. Anderson, W. H. Long. Sugarcane Borer Resistance to Insecticides. J. Econ. Entomol., 1122-24 (1965).

SUGARCANE MOSAIC IN LOUISIANA:
SOME ASPECTS OF A CHRONIC PROBLEM

G.T.A. Benda, Houma Louisiana

Fifty years ago, E. W. Brandes (1920) discovered that the corn leaf aphid was capable of transmitting sugarcane mosaic virus; this was a remarkable achievement, for in that day it was possible to read the entire plant virus literature in English on a Sunday afternoon and have time for a walk, too. The great epidemics of that time which threatened the industries of several countries gave to mosaic a notoriety that it has not lost since (Edgerton, 1959). The advances made in strain determination and strain identification were summarized about 20 years ago (Summers, Brandes, and Rands, 1948). It then appeared that the sugarcane breeders had solved the problem of mosaic through the development of resistant varieties; these varieties were developed by the use of genetic material resistant to the strains then current. Within the last 15 years, strain H has been isolated in Louisiana (Abbott, 1961 a; Abbott and Tippett, 1966); this strain spread rapidly through C.P. 44-101, the most widely planted of the resistant varieties (Abbott, 1962). Today, sugarcane breeders have developed varieties that incorporate considerable resistance to strain H (Breaux and Dunckelman, 1969); and the work is continuing to select new varieties with higher levels of resistance.

The sugarcane mosaic disease might be considered in terms of the symptoms that it causes and the damage that it does. In the leaf symptoms of mosaic, "the cells of the chlorotic areas are inhibited so that there is reduced growth with little or no differentiation of cell and tissue structure...The chloroplasts of the chlorotic areas are small and few in number as a result of the inhibitory action of the disease." The chlorotic areas are most evident in the young, rapidly growing leaves; the older leaves appear more normal as "chlorotic areas tend to develop the normal green color with age" (Cook, 1930). The effects on tissue differentiation and chloroplasts are characteristic of the mosaic symptom (Cook, 1930; Esau, 1968). In some varieties, there may be striking symptoms on the stalk (Edgerton, 1959). In affected cells of corn, the virus may cause a pinwheel-like inclusion (Edwardson, 1966). As to the damage, the mosaic disease causes poor growth of diseased plants and loss in yield through reduction in tonnage (Abbott, 1961 b). The stubbling ability of diseased cane is lessened under field conditions.

The sugarcane mosaic disease in Louisiana might also be discussed in terms of the history of the varieties that were flawed by it. First to go were the noble varieties that had been the basis of the Louisiana industry since its beginning; next the early Javanese varieties, like P.O.J. 36, 213, and 234, became diseased; then the Indian varieties, Co. 281 and Co. 290 followed them, and so on to the present. It is a cycle of varietal propagation, disease and replacement repeated over and over for the past 40 years.

In developing the subject of why mosaic is still a problem, I should like to emphasize than an epidemic depends on the interactions of the basic factors, the virus, the plant, and the vector; the vectors are those species of aphids which can transmit the virus from one plant to another. The interaction between plant and virus constitutes the disease, and the interactions between virus and vector, and between vector and plant, determine the incidence of the disease. The incidence and severity of the disease determine the economic importance of the outbreak. I shall briefly discuss the interactions of plant and virus, both as regards the development of the disease and as regards the formation of new strains; I shall then consider the interactions that the vector has in spreading the disease; and I shall conclude by considering how the situation in Louisiana may contribute to the development of important new strains of mosaic.

1. Plant and Virus Interaction:

A. The Disease

Basic to any consideration of a disease are the interactions of the plant host and the pathogenic virus. It is essential that the common use of the term mosaic in the singular should not obscure the plurality of interactions between sugarcane variety and mosaic virus strain.

Infection is a continuous process, from the entry of the virus into the first cell until the plant is fully diseased (Bawden, 1964). The process may be divided into four stages, to represent the major types of obstacles that the virus must overcome if it is to cause the typical disease.

The first obstacle for the virus is the infection of the initial cell. This stage encompasses all of the changes necessary in virus and affected cell to allow the virus to begin the infection. In order to introduce the virus into the cell, a wound seems to be required, although there has been much controversy over the severity of the wound. The association of virus and initial cell is a fragile one, and not again in the whole course of infection can so many factors influence the outcome. One group of substances hinders the initiation of this infection, and these substances are known as inhibitors. Some years ago there was interest in the use of milk as an inhibitor (Anzalone, 1962). Milk and other inhibitors when applied to the plant are effective in reducing the frequency, but not in eliminating the successful encounters of virus and initial cell. As infection is not stopped entirely by inhibitors applied to the plant, inhibitors used in this way tend to be useless as a control measure.

The second kind of obstacle is the requirement for cell-to-cell movement of the virus. Unless a new infection is to occur, the virus is restricted in its movement to living cells. Each cell in the plant touches upon one or more other cells. In the process of cell-to-cell movement, the virus begins its spread through the epidermal and parenchyma tissues. The movement tends to be slow, a fraction of an inch a day; the virus multiplies and uses each cell that it infects as a gateway to the neighboring uninfected cells.

The third kind of obstacle for the virus is the need to enter the phloem and the need to leave it. The phloem is the food conducting tissue of the plant. The sieve elements of the phloem are cells specialized in the movement of sugar and other organic molecules, and it is in these elements that virus particles may be moved quickly and over long distances, from leaf to stem, to roots, to young leaves, and to leaf primordia. Once a virus particle enters into a sieve element, it is carried passively in a stream moving many inches an hour. The direction in which the stream moves is determined by factors outside the sieve elements, and the particular place on the route where the virus particle leaves the stream seems to be determined by chance. Once out, the virus particle may multiply, and move from cell to cell, as described above.

The fourth obstacle to the full expression of the disease is symptom formation, the degenerative changes in some infected cells. This is the only part of the infective process whose effects are visible with the naked eye. It should be emphasized that this stage need not follow on the previous three stages.

All four stages of a virus disease may be influenced by a brief treatment with high temperature (Yarwood, 1965). The heat treatment of sugarcane for the control of the ratoon stunting disease increases its susceptibility to infection with mosaic (Bourne, 1962; Zummo, 1967). Evidence indicates for at least one variety-strain combination that the effect of this heat-treatment is to increase the movement of mosaic in the plants (Benda, unpublished).

It is possible to classify the response of a particular variety to a particular strain of mosaic virus. The classification of immune, resistant, and susceptible responses is based on the incidence of disease and on the severity of the damage (generally measured as effect on yield) resulting from the disease.

A plant is said to be immune if there is no infection and no damage beyond that incident to inoculation. The plant may be said not to be susceptible to the initiation of infection.

A variety is said to be resistant if the incidence of infection is low. Obviously, this concept implies a comparison and requires the comparison to be completed. The incidence of infection is low in a resistant variety when the incidence in a susceptible variety is high, all other things being equal. Among the plants of one variety, however, those that do become infected after inoculation may be assumed to be genetically identical to those that do not.

Resistance may result from a lesser susceptibility to initiation or infection, or a lesser susceptibility to cell-to-cell movement, or a lesser susceptibility to phloem entry and exit, or to a lesser susceptibility to symptom formation, or to any combination of such lesser susceptibilities. Resistance emphasizes what did not happen, the number of times that infection has not gone to completion. The usefulness of the term resistance lies in its vagueness, the danger lies in the possibility that resistance may be considered a single indivisible property for all varieties.

Susceptibility emphasizes what does happen, that all four kinds of obstacles may be surmounted regularly. Susceptible varieties are subdivided depending on the damage done by the disease; if the damage is relatively minor, the variety will be said to be tolerant; if relatively major, intolerant.

The damage done by disease depends on the age at infection and the conditions surrounding the onset of disease. It may be stated as a rule of thumb, that for the fullest expression of symptoms, it is necessary to have young plants growing vigorously. Older plants, or plants growing poorly generally show less severe damage.

The plant has various defenses against mosaic virus infection. Rather than discuss those defenses which depend on escaping infection such as being unattractive to aphids, I would like to discuss two types of defense that can occur in plants that become infected.

The first line of defense may be considered developmental. It is the common experience of those working with mosaic that as a susceptible plant grows older successful infections decrease; as with the plant, so with the individual leaf. How this apparent resistance originates is not clear, but it is not likely to result from difficulties in forming symptoms; the continued production of symptoms on plants infected earlier argues against this. It is probable that the virus of a new infection in an older leaf or plant, on entering the phloem, is moved passively with the organic materials to the storage tissues where it is trapped. The progressive restriction on virus movement is indicated also by the observation of the distribution of symptoms among the stalks of a stool. In the spring, a mother shoot and all the tillers are likely to show infection, whereas in the fall it is possible to find stools with only a single stalk diseased.

A plant that is infected with virus may lose the virus (Summers *et al.*, 1948; Forbes and Mills, 1943). This phenomenon, called recovery, is a property of specific variety-strain combinations. Thus, there are varieties that recover from one strain, but not from another, and there are varieties that recover from all strains, and varieties that do not recover from any strain (Benda, unpublished). Usually, the virus is lost when a new shoot develops from the axillary bud of an infected cane stalk; but there are numerous recorded cases in which the symptoms (and presumably the virus) are lost in the growth of a single stalk (Summers *et al.*, 1948). The mechanism of virus loss is unknown.

In the field, recovery can have the effect of reducing the damage by reducing the incidence of the disease (Summers *et al.*, 1948; Edgerton, 1959). If recovery could be systematically exploited under conditions of moderate disease pressure, it could form a valuable control for the damage of mosaic. Unfortunately, there is not early test for recovery which could be used in screening large populations of seedlings to permit selection for this trait (Azab, Mills, and Chilton, 1959).

B. Strains and their Formation

If we turn our attention from the responses of a plant to infection, it might be well to consider the influence that the plant has on the virus.

The virus of sugarcane mosaic, like other viruses, needs the machinery available in the living cell to make more virus, identical to itself (Bawden, 1964). The virus in the development of disease repeats the processes of invasion of new cells and multiplication again and again.

As in all organisms, there are errors in the copying of the hereditary information of the virus. Such errors occur with a frequency that can only be estimated rather indirectly (Price, 1964). It seems safe to guess that with the large number of virus particles formed per plant, copying errors would occur many thousands of times in each infected plant.

It is probable that in these copying errors, new strains have their origin. But it is a long way from copying error to new strain. There is little chance of survival, for most changes would be detrimental to the delicate balance of properties that makes a virus successful in a plant; but even if the change were beneficial to the new strain, it still needs to be spread to survive. Spread of virus under field conditions requires that a vector aphid feed on the part of the plant where the new strain is dominant and transmit it to a healthy plant. There is a biological liklihood to the formation of new strains; the event itself is not likely, but there are many chances for the event to take place.

The new strains of most interest, from a practical standpoint, are those that extend the host range of the virus. If a new strain can successfully infect previously resistant varieties, it has a niche without direct competition from other strains.

Strains of a virus differ among themselves in their physical and chemical properties and in the symptoms that they cause (Summers _et_ _al_. 1948; Abbott and Tippett, 1966). The more criteria used in strain identification and the more rigidly each criterion is defined, the greater the number of strains that can be identified. There is no answer as to the number of strains in existence. For survey purposes in Louisiana, the strains are identified in five groups, designated A, B, D, H, and I, a recently described strain (Tippett and Abbott, 1968). In a survey of mosaic strains from various localities in the world, the main strains isolated belonged to A, B, and D, although also noted were various isolates that did not fit into the known categories (Abbott and Stokes, 1966).

The strains of mosaic are slow to change (Abbott and Tippett, 1966). It seems possible to go out now and find isolates of strains A and B which are identical to those of 30 years ago. An explanation may depend on the culture of sugarcane itself. When a single variety of sugarcane is considered in relation to mosaic virus, three points may be made: first, each variety acually represents genetic constancy. There is little evidence for mutation despite repeated attempts to select sports in characteristics other than stalk color; secondly, the same variety may be grown for many years and in many places; thirdly, there is a tendency to cluster varieties genetically. The parents of a successful cross, or a successful variety itself, are crossed repeatly to produce new varieties which may be quite closely related in their response to mosaic virus.

Prolonged use of a sugarcane variety would have the effect of slowing change in strains. If a variety is susceptible, and a plant of that variety becomes infected with a strain of virus to which that variety is well-adapted, then any new strain formed in that plant is likely to have a difficult time to compete successfully, even to compete successfully enough to become the dominant strain just in a single part of the plant Unless it does, it will be lost with the plant.

This reasoning is based on the fact that one plant can support several strains of virus at the same time (Abbott, 1963; Abbott and Tippett, 1966). Since the first studies on tobacco mosaic, it has been assumed that the strains compete for susceptible cells, for the cellular machinery to make more virus, and for invasion of the neighboring cells as yet uninfected (Thung, 1935). In this type of competition, the original strain tends to win--that is how it has survived so long.

If a variety is resistant, then the new strains that are transmitted to it may test the mechanism of resistance in the total duration of the variety, and if the mechanism of resistance is passed to its progency varieties, in their duration also. Once the particular mechanism of resistance has been breached by a new strain, there will presumably, be lively competition between the new strain and the strains derived from it, until one strain becomes stabilized. The aphids then will ensure that the stabilized strain becomes widely distributed.

II. The Interactions of Vector and Plant and of Vector and Virus

In the spread of the mosaic disease, the vector plays an essential role. Published results indicate that seven species of aphids are capable of transmitting sugarcane mosaic virus from sugarcane to sugarcane (Abbott and Charpentier, 1962). In addition, the green peach aphid can transmit the virus in sorghum, but apparently not from sugarcane to sugarcane (Anzalone and Pirone, 1964). The manner in which the aphids transmit this virus suggests that the virus is carried on the mouth parts. In this type of vector, the time required for transmission is brief (Zummo and Charpentier, 1964, 1965, 1967), and the actual process of acquiring the virus or of infecting a healthy plant is a matter of seconds (Bradley, 1964).

Each species of aphid may have two or more species of plants that it colonizes in the course of a year. On these plants, the aphids, under favorable conditions, reproduce very rapidly as non-winged forms.

When conditions become unfavorable, winged forms of aphids are produced. Many factors have been found to stimulate the production of winged forms. Among these are the dying of the plant that is being colonized; overcrowding; long nights; high day temperatures; and low humidity. The winged forms may be carried long distances by the wind; unless the wind velocity is high, the aphids can land where they are attracted. Where the wind velocity is low, less than a few miles per hour, the aphids can take off, direct their flight and land, more or less at will.

Aphids have various natural enemies that feed upon them or their young; they also have friends in various species of ants that will help to distribute them. Some years the climate is right, and there is a large crop of winged aphids extending over a long period; in other years, winged aphids are fewer, and they are present relatively briefly.

The relationship of sugarcane to the vector species is somewhat unusual in plant virology because only one of the vector species, the rusty plum aphid, occurs on sugarcane regularly; and only two, the rusty plum aphid and the corn leaf aphid colonize sugarcane (Ingram, Haley, and Charpentier, 1939; Charpentier, 1963).

There has been no success in controlling the spread of a virus disease by the use of systemic insecticides when the vectors responsible for the spread come into a crop from the outside. In sugarcane, although the virus has to be picked up in the crop, the brief time required to do this, and to transmit the virus would tend to make systemic insecticides ineffective (Zummo and Charpentier, 1964). It may be assumed that winged aphids coming into sugarcane from other host plants would be restless and move from plant to plant without extensive feeding. This behavior pattern is ideal for spreading the disease and for delaying the effect of the systemic insecticide until much virus transmission has occurred. The results of field experiments have shown excellent control of aphids but not of spread of mosaic (Charpentier, 1956; Charpentier and Zummo, 1964).

The infestation of a neighboring crop by vector aphids may (Abbott and Charpentier, 1962), or may not (Ingram, Haley, and Charpentier, 1939), influence the vector population on sugarcane, depending apparently on whether the aphids are overcrowded and whether or not the preferred crop is disturbed.

The transience of the population of winged aphids makes it difficult to sample the aphids on the plants, and, indeed, they may be overlooked altogether. In order to estimate the population in flight, the entomologists use traps and, by counting the aphids trapped at weekly intervals, obtain information on the numbers and kinds throughout the year. From these data are calculated the periods of greatest flight for all aphids as a group, and for each species separately (Komblas, 1964).

The relation of relative frequency of aphids and the spread of mosaic is not as direct as one would like. There is a much higher frequency of winged aphids in the spring than in the fall (Komblas, 1964). Does this indicate much more spread in the spring? Not necessarily. Not all species of winged aphids are more frequent in the spring and the two species that can colonize cane are more frequent in summer and fall (Komblas, 1964). Also, there is some difficulty in relating frequencies to populations. The spring frequencies may represent such a large population of aphids that a small fraction of that population, at a time when the plants are susceptible, may be sufficient to transmit amply. The field experience in Louisiana indicates that there is spread both in the spring and in the fall (Summers, et al., 1948; Zummo, 1963; Steib, unpublished).

There is another factor to be considered in aphid spread of mosaic virus. The aphid species (and, presumably, the races of a species also) may vary in their efficiency to transmit the virus. Results have indicated that the corn leaf aphid is a better vector than the rusty plum aphid (Ingram and Summers, 1936) and the greenbug (Ingram and Summers, 1938), and that the brick-red sowthistle aphid is a better vector than the pea aphid (Abbott and Charpentier, 1962).

The virus that is spread by the winged aphids is believed to come largely from sugarcane and not from other hosts of the disease. With the modern weeding practices that result in the more efficient control of crabgrass and other wild grasses, the possibility that mosaic is carried in from weed species has been reduced.

The varieties differ as source plants of virus for the aphid vectors in the field. Unfortunately, the evaluation of a variety as a virus source is entangled in data on field incidence of infection and on resistance to spread. Varieties that are highly resistant to the current strains of virus, such as C.P. 36-13 and C.P. 47-193, are poor field sources of virus, presumably through their resistance to infection and the resulting low incidence. These varieties have been used as buffer cane to retard the spread of mosaic from areas more infected to areas less infected (Abbott, 1962). On the other hand, varieties with a high incidence of mosaic are good sources of virus in the field. The variety N.Co. 310 is reputed to be the outstanding virus source, even above its susceptibility. It remains to be determined by future research whether vector preference (Charpentier, 1963) or the virus being more readily available justify the reputation of this cane.

The most effective control to the spread of virus by aphids is to remove the source of virus. This is done by roguing, a practice in which sugarcane with symptoms of mosaic is removed.

The theory of roguing is simple, but the practice is difficult (Abbott, 1962). There are various misconceptions about roguing which I would like to mention in passing.

A grower with very little mosaic may feel that there is no hurry to rogue as he will get it all later and at one time. The point is that he is leaving a source of virus for the aphids. It is possible that aphids would be attracted to the more yellow tint of the diseased plants. Mosaic-infected plants, if visited with somewhat higher frequency by aphids, could serve as a more effective source of virus than their part in the whole population would suggest.

A second misconception is that the function of roguing is to reduce the percentage of mosaic in the seedcane that is to be planted in August or the fall. The cutting out of diseased cane in the summer (Steib and Chilton, 1967) is no substitute for roguing. Roguing is to prevent spread, cutting out is to cure the spread that has occurred. There may be some question as to whether an ounce of prevention is worth a pound of cure, but there should be no doubt that they are not the same. The recommendations urge the grower to prevent what can be prevented and to cure what cannot (Anon., 1969).

A third misconception is that there is a threshhold of incidence of mosaic beyond which there is no point to rogue. The serious decision to abandon roguing of seedcane has to be based on the various circumstances operative at the farm, not on some general percentage. Among the factors to be weighed, besides the availability of labor and cost, are the varieties being grown (their susceptibilities to spread and damage), future plans for varieties, the incidence of mosaic on the plantation, and the incidence of mosaic on neighboring properties. A grower who abandons roguing and finds himself with ever increasing amounts of mosaic, becomes restricted progressively to the so-called tolerant varieties, N. Co. 310 and C.P. 44-101. The newer varieties are not selected for tolerance but for resistance; they have neither the tolerance of the two older varieties, nor unlimited resistance to withstand the inoculation pressure that would occur if they were planted among thoroughly infected cane (Fanguy and Tippett, 1968).

Roguing presupposes that the aphids pick up the virus after they have entered the sugarcane fields. Were the aphids to pick up the virus before they enter, the effectiveness of roguing would be very much curtailed. This is one serious aspect of the occurrence of mosaic on grasses other than sugarcane in a sugarcane area, whether these be weeds, corn, or sorghum. A second serious aspect is the tendency of each kind of plant to favor a particular strain of virus over other strains; the non-sugarcane species, many of which grow from seed, offer a far more varied genetic base, and thus may well hasten the development and spread of new strains of virus.

III. Plant, Virus, and Vector Interaction

To have an epidemic under field conditions, there is need for virus, vector, and susceptible plant. These conditions are more or less met each season. But an epidemic of mosaic is not as inevitable as such a listing would suggest. There are locations in Louisiana where there is little mosaic spread and other areas where there is much; it has been difficult to explain the local differences. What has made the research that would be needed quite unappealing is a feeling that these local phenomena may result from combinations of aphid dynamics and plant variability which alter from one situation to another and possibly from one year to the next.

When one turns from this localized variation to large-scale geographical differences, as between Louisiana and tropical America, for example, one notes a striking difference: Here mosaic is a problem, there it is not. The explanation is as direct: Here there is strain H, there there is not. To the optimist, the origin and dispersal of strain H is a unique phenomenon that could have happened anywhere. To the pessimist, it is a phenomenon more likely to occur here than almost anywhere else. The following is the opinion of one pessimist.

The crucial factor in the dispersal of new strains, and I assume that potential new strains are constantly formed in the multiplication of virus, is to have aphids and susceptible plants. Sugarcane seems to be susceptible to an infection leading to symptoms only when the mother shoot or tillers are small, before the elongation of internodes.

The aphids occur here in quantity throughout the time that the cane is small; and the climate in Louisiana is such as to keep the cane small for a long time. During the autumn the cane grows after planting, if the planting was early, and after harvesting; occasional frosts kill back much of the leaf surface; the leaves regrow between frosts; then, when the frosts are over, the cool nights of spring retard stalk growth and favor tillering. Cane planted in August, with several inches of soil added before the first frost, may show some green continuously for eight months before the first elongate internode. In the fall, the small cane is exposed to the aphids moving from their dying host plants and from the harvested sugarcane. In the spring, the small cane is exposed to the aphids from the dying winter weeds. The condition of cane in Louisiana may be described as a super-abundance of infancy with double jeopardy from aphids.

North of us, the winter permits neither the growth of cane nor of the winter weeds so plentiful as a source of aphids. South of us, the winter is too mild to interfere extensively with the development of cane, so that the susceptible stage is brief.

To conclude, then, after wading through these interactions of varieties, strains, and aphids: "Why is mosaic still a problem?"

The answer may rest in a story told about the philosopher Wittgenstein. A student came to him and said: "I have a problem. I do not feel at home in the universe." He answered, "That is not a problem. That is a predicament."

Literature Cited

Abbott, E. V. 1961a. A New Strain of Sugarcane Mosaic Virus. Phytopathology 51: 642. (Abstr.)

__________. 1961b. Mosaic, p. 407 to 430. In J. P. Martin, E. V. Abbott, and C. G. Hughes. Sugarcane Diseases of the World, V. I. Elsevier, Amsterdam.

__________. 1962. Problems in Sugarcane Disease Control in Louisiana. I.S.S.C.T. (Mauritius), Proc. 11: 739-742.

__________. 1963. Cross-protection Experiments with Sugarcane Mosaic Virus (SMV). Phytopathology 53: 869 (Abstr.)

__________, and L. J. Charpentier. 1962. Additional Insect Vectors of Sugar Cane Mosaic. I.S.S.C.T. (Mauritius), Proc. 11: 755-760.

__________, and I. E. Stokes. 1966. A World Survey of Sugar Cane Mosaic Virus Strains. Sugar y Azucar. 61(3): 27-29.

__________, and R. L. Tippett. 1966. Strains of Sugarcane Mosaic Virus. U. S. Dept. of Agric. Tech. Bull. 1340. 25 p.

Anon. 1969. Recommendations for the Control of Mosaic Disease in Sugarcane in Louisiana 1969. Sugar Bull. 47(11): 13.

Anzalone, L., Jr. 1962. Inhibition of Sugarcane Mosaic Virus by Milk. Plant Disease Reptr. 46: 213-215.

__________, and T. P. Pirone. 1964. Transmission of Sugarcane Mosaic Virus by Myzus persicae. Plant Disease Reptr. 48: 984-985.

Azab, Y. E., P. J. Mills, and S. J. P. Chilton. 1959. Studies on Recovery of Sugarcane Seedlings from Mosaic. I.S.S.C.T. (Hawaii), Proc. 10: 1050-1053.

Bawden, F. C. 1964. Plant Viruses and Virus Diseases. 4th ed. Ronald Press and Co., New York. 361 p.

Bourne, B. A. 1962. Some Basic Research Concerning Mosaic Disease Susceptibility in Sugar Cane. Sugar Journal 25(3): 25-26, 28-30.

Bradley, R. H. E. 1964. Aphid Transmission of Stylet-borne Viruses, p. 148 to 174. __M.K. Corbett and H. D. Sisler (ed.) Plant Virology. Univ. Florida Press, Gainesville.

Brandes, E. W. 1920. Artificial and Insect Transmission of Sugarcane Mosaic. J. Agric. Res. 19: 131-138.

Breaux, R. D., and P. H. Dunckelman. 1969. Variety and Mosaic Strain Interaction in Sugarcane. Sugar y Azucar (in press)

Charpentier, L. J. 1956. Systemic Insecticide Studies for Control of Vectors and Sugarcane Mosaic in Louisiana. J. Econ. Entomol. 49: 413-414.

__________, 1960. Sugarcane Mosaic-Vector Studies in Louisiana. Amer. Soc. Sugar Cane Technol., Proc. 7B : 247-259.

__________, (and N. Zummo). 1964. Field Experiments with Insecticides for Control of Insect Vectors and Sugarcane Mosaic Spread. Sugar J. 27(3): 17-19.

Cook, M. T. 1930. The Effect of Some Mosaic Diseases on Cell Structure and on the Chloroplasts. J. Dep. Agric. Porto Rico 14: 69-101.

Edgerton, C. W. 1959. Sugarcane and Its Diseases. Louisiana State Univ. Press, Baton Rouge. 301 p.

Edwardson, J. R. 1966. Electron Microscopy of Cytoplasmic Inclusions in Cells Infected with Rod-Shaped viruses. Amer. J. Bot. 53: 359-364.

Esau, Katherine. 1968. Viruses in Plant Hosts. Univ. Wisconsin Press, Madison. 225 p.

Fanguy, H. P., and R. L. Tippett. 1968. Variety Yield Trials Used to Measure Rate of Mosaic Spread in Sugar Cane. Sugar y Azucar 63(5): 56-57.

Forbes, I. L., and P. J. Mills. 1943. Disappearance of Virus From Mosaic-Diseased Sugarcane Plants. Phytopathology 33: 713-718.

Ingram, J. W., W. E. Haley, and L. J. Charpentier. 1939. Insect Vectors of Sugarcane Mosaic in Continental United States. I.S.S.C.T. (Louisiana), Proc. 6: 483-495.

__________, and E. M. Summers. 1936. Transmission of Sugar Cane Mosaic by the Rusty Plum Aphid, *Hysteroneura setariae*. J. Agric. Res 52: 879-887.

____________________. 1938. Transmission of Sugarcane Mosaic by the Green Bug (*Toxoptera graminum* Rond.). J. Agric. Res. 56: 537-540.

Komblas, K. N. 1964. Field Studies of Aphid Vectors of Sugar Cane Mosaic and Methods of Control. Ph.D. Thesis. Louisiana State Univ., Baton Rouge.

Price, W. C. 1964. Strains, Mutations, Acquired Immunity, and Interference, p. 93 to 117. *In* M. K. Corbett, and H. D. Sisler (ed.). Plant Virology. Univ. Florida Press, Gainesville.

Steib, R. J., and S. J. P. Chilton. 1967. Removal of Mosaic Diseased Stalks in July with a Sugar Cane Knife Found to Reduce Mosaic in Seed Cane. Sugar Bull. 45(7): 98-101.

Summers, E. M., E. W. Brandes, and R. D. Rands. 1948. Mosaic of Sugar Cane in the United States, with Special Reference to Strains of the Virus. U. S. Dept. Agric. Tech. Bull. 955. 124 p.

Thung, T. H. 1935. Infective Principle and Plant Cell in Some Virus Diseases of the Tobacco Plant. II. 7e Ned. Ind. Natuurw. Congress, Hand.: 496-507.

Tippett, R. L., and E. V. Abbott. 1969. A New Strain of Sugar Cane Mosaic Virus in Louisiana. Plant Disease Reptr. 52: 449-451.

Yarwood, C. E. 1965. Temperature and Plant Disease. World Rev. Pest Control 4(2): 53-63.

Zummo, N. 1963. Spread of Sugarcane Mosaic in the Fall in Louisiana. Sugar Bull. 41(24):298-300.

__________. 1967. Effect of Treatment of Seed Cane on Susceptibility of Sugar Cane to Sugar Cane Mosaic Virus. Phytopathology 57: 83-85.

Zummo, N., and L. J. Charpentier. 1964. Vector-Virus Relationship of Sugar Cane Mosaic Virus. I. Transmission of Sugar Cane Mosaic Virus by the Brick-red Sowthistle Aphid (*Dactynotus ambrosiae* Thos.). Plant Disease Reptr. 48: 636-639.

____________________. 1965. Vector-Virus Relationship of Sugar Cane Mosaic Virus. III. Transmission of Sugar Cane Mosaic Virus by the Rusty Plum Aphid (*Hysteroneura setariae* Thos.). Plant Disease Reptr. 49: 827-829.

Zummo, N., and L. J. Charpentier. 1967. Vector-Virus Relationship of Sugar Cane Mosaic Virus. Transmission of Sugar Cane Mosaic Virus by the Corn Leaf Aphid, *Rhopalosiphon maidis* (Fitch.). I.S.S.C.T. (Puerto Rico), Proc. 12: 1089-1092.

FERMENTATIVE UTILIZATION OF SUGAR CANE BAGASSE[1]

Charles E. Dunlap and Clayton D. Callihan
Chemical Engr. Dept., L.S.U.
Baton Rouge, Louisiana

The world production of sugar cane bagasse during the 1966/67 grinding season was about 51,000,000 U.S. tons on a moisture-free basis. Of this very appreciable, and increasing amount, only a small fraction found use other than as fuel for sugar mill boilers. Recently, however, there has been increased cognizance of the fact that improved processing techniques and rising raw materials costs have greatly enhanced non-fuel uses for this material. An increasing fraction of bagasse is being used for wall board and insulation board manufacture; new and better methods of de-pithing and storage have resulted in increased bagasse paper pulp production; and processing bagasse for furfural and other chemicals has increased. Nevertheless, the majority of bagasse still find final usage as boiler fuel.

The economic value of bagasse has been set as equal to fuel replacement value, usually about $6.00 to $8.00 per dry ton, depending on local fuel costs, with equal value being given for pith and fiber. When sold by the mill for non-fuel use, an additional $0.40 to $0.50 per ton is paid as premium. If the bagasse is sold for paper pulp manufacture, it must be depithed, whether at the sugar mill or at the final pulp mill. This operation further raises the cost of the bagasse fiber by about 1 per dry ton. The bagasse pith which comprises 25% to 35% of the bagasse dry weight is unusable and unacceptable for paper manufacture, and must ultimately be disposed of or used as boiler fuel.

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[1] This work was sponsored by funds from the American Sugar Cane League and the Graduate Research-Council of Louisiana State University, Baton Rouge, Louisiana.

Bagasse de-pithing may be accomplished most economically by partial humid or wet de-pithing at the sugar mill, and final de-pithing at the pulp mill.

The importance of paper pulp production from bagasse has recently been considerably enhanced by new and more economical de-pithing and storage techniques, and by the recent realization of future demands for cellulosic fibers of paper and paperboard in 1975 will reach 178,000,000 U. S. tons. This represents a tremendous increase over the current level of consumption. In 1965 total pulp production was almost 92,000,000 U. S. tons, and predictions are for 149,000,000 U. S. tons by 1975 (Atchison, 1968). This will leave 29,000,000 U. S. tons of pulp to be made up by re-use and fiber sources. The future use of bagasse for paper manufacture should, therefore, expand greatly. Concurrent with this increased usage, there will be a proportional increase in bagasse pith production.

The pith fraction of whole bagasse is, in general, quite similar in chemistry to the fiber portion. It has, however, a more motley carbohydrate content than fiber, with more hemi-celluloses such as xylan, glucan, mannan, and polyuronide fractions of xylose, arabinose, and glucose. Various pentosans are also present. The cellulose fraction of pith, while being of almost the same relative size as in fiber, has distinctly different physical properties. It is much less highly polymerized, less tightly bound, and more amorphous. The cellulose fibrils are, therefore, shorter and more easily separable; but of little use as physical fiber units.

It is then to a non-fiber, non-fuel usage of bagasse--and more specifically bagasse pith--that we shall turn our attention.

Fermentation of cellulose is certainly not a new idea, but it is a concept that has failed to find much application in a peacetime economy.

Viewed as a fermentable carbohydrate, cellulose differs rather radically from those carbohydrate substrates in general use. It is insoluble, it is polymerized by a 1-4 beta, glucosidic linkage, it generally has a highly ordered crystalline fraction, and it is invariably found closely associated with hemicelluloses and lignin. The use of cellulose as a microbial substrate adds but one step to the overall mechanism of carbohydrate fermentation. The cellulose must be solublized before entering cell metabolic pathways. The solublization is an enzymatic step catalyzed by the cellulase enzyme system of some bacteria and fungi.

The action of fungal and bacterial cellulase enzyme systems on native and regenerated celluloses is governed by several chemical and physical properties of the substrate. Enzyme hydrolysis of native cellulose has been shown to have two-stage kinetics; the first stage quite rapid, but the second relatively slow. This was explained on the basis of the two phase nature of cellulose, hydrolysis proceeded rapidly through the amorphous phase and more slowly in the crystalline region. An inverse correlation was found between cellulose relative crystallinity and susceptibility to enzyme attack (Siu, 1951).

Another factor apparently affecting the bio-degradability of native cellulosics is the presence of lignin. Lignin level has been shown to be inversely correlated with cellulose degradability, but more importantly -- for it gives a clue to the true nature of the lignin effect -- is the decrease in cellulose reactivity with increasing age of the plant while lignin concentration remains essentially constant (Quicke and Bentley, 1959). The fact that lignin becomes more highly condensed and more occlusive to the cellulose as the plant ages has been cited as the reason for the increased inhibitory effect.

Native cellulosics all contain varying amounts of hemicelluloses, the hexoses of which are more easily solublized and more bio-degradable than the true cellulose (Keys and Van Soest, 1967). The decreased rate of enzymatic hydrolysis of some partially acid hydrolyzed cellulosics (hemicelluloses were removed) has been explained on the basis of the hemicelluloses acting as spongy or porous "filler" between fiber bundles or layers of cellulose. This porous filler is easily penetrated by solvents or enzymes, and provides access to cellulose in the interior of the cellulose physical structure. When these hemicelluloses are removed, the interstitial areas close, and cellulose availability is limited to the exterior of the fiber bundle (King, 1968).

If we now match the chemical and physical properties of bagasse pith to those criteria that would seem to promote rapid and thorough enzyme decomposition, it is seen that in almost every case pith qualifies as an excellent substrate.

A process has been developed at LSU whereby native cellulosics such as bagasse, straws, grasses, etc. are treated with a mild alkali oxidation treatment to enhance those properties that effect cellulose bio-degradability. The aims of the treatment process are:

1. To decrease cellulose relative crystallinity.
2. To remove lignin, or disrupt its physical structure.
3. To increase the amount of water soluble carbohydrate in the treated substrate.
4. To obtain the above changes at a competitive cost.

Whole sugar cane bagasse was the primary cellulosic investigated during the preliminary study. An average component analysis of bagasse before and after the treatment process shows that the carbohydrate fraction remaining in the bagasse after a water extraction is increased from about 57% to almost 75%. The fraction of carbohydrate that is water soluble rises from about 2% to almost 18%. This rise in relative carbohydrate content is caused by preferential removal of non-carbohydrate components such as resins, gums, lignin, fat, protein and dirt. The increase in water soluble carbohydrate is caused by the oxidative de-polymerization of a fraction of the cellulose present.

Bagasse showed about a three-fold decrease in degree of polymerization during the treatment; averaging a D.P. of over 800 before treatment, and less than 300 after the process. The overall degree of relative cellulose crystallinity also was lowered from about 50% to 10% by the treatment.

Fifteen different cellulosics were treated in the laboratory, and the biodegradability of their cellulose fractions determined by the *In Vitro* rumen fluid method of Baumgardt (1962.) The treatment increased cellulose digestibilities on an average of 85%. Some examples are:

	(% Dry Cellulose Digested)	
	Untreated	Treated
Bagasse, whole	15.1	57.0
Bagasse, pith	26.5	55.0
Bagasse, fiber	30.1	50.3
Rice straw	7.3	54.1
Johnsongrass	66.5	88.0
Prairie grass	16.2	45.7
Corn cobs	19.3	44.0
Oat straw	35.5	66.0
Wheat straw	25.4	44.0
Sorgo bagasse	30.2	61.5

Concurrently with our work on cellulosic treatment, Dr. V. R. Srinivasan and Y. W. Han (1968) of the Louisiana State University Department of Microbiology isolated a celluloytic bacterium which they identified as of the genus *Cellulomonas*. The bacterium would attack native cellulosics, and had rapid growth rates and simple nutrient demands.

The organism was aerobic, had an optimum growth temperature of about 30°C, and optimum growth at a pH of 6.5 to 7.0. The cultures had mass doubling times of from 2 to 5 hours when grown on treated bagasse or pure cellulose (Solka Floc) supplemented initially with glucose. A small initial amount of yeast extract was necessary for the culture to flourish and to develop a characteristic yellow color.

The organism needed a small (≤ 0.6 grams/liter) initial amount of a soluble carbohydrate in the medium to prevent a prolonged lag phase. Treated bagasse would provide this immediately available carbohydrate, but pure cellulose had to be supplemented with an initial amount of glucose.

Several pounds of *Cellulomonas* cells grown on purified cellulose were harvested and lyophilized. Dr. S. P. Yang (1968) of the Louisiana State University Department of Home Economics analyzed these for crude protein and amino acid pattern, and conducted feeding studies on rats.

The cells contained 52.3% crude protein (N x 6.25), and had a good amino acid profile. Various experimental diets were fed to male weanling rats for 10 days. It was found that *Cellulomonas* cells were superior to *Pseudomanas* produced on hydrocarbons, but inferior to casein.

The rats held their weight on a diet with 20% protein supplied by *Cellulomonas*, and showed good gains on a diet containing 40% *Cellulomonas* protein. The cells were non-toxic at all levels fed (up to 76% by weight of the diet).

Addition of L-methionine improved the quality of the protein considerably. High fecal nitrogen content of the rats fed intact *Cellulomonas* cells indicated that cell membrane rupture was incomplete. It is felt that cell homogenization or lysis prior to feeding will improve the utilization efficiency.

An economic analysis was prepared for a proposed plant utilizing sugar cane bagasse as the cellulosic raw material to produce 10,000 tons of dry cell product per 340 day year (Callihan and Dunlap, 1968). For the purpose of estimation, it was assumed that the culture could be continuously maintained at a cell density of 10 gms. per liter at a culture mass doubling time of 2 hours.

The total manufacturing cost of about 6.7¢ per pound of dry cell product compares very favorably with cost estimates of SCP produced from hydrocarbons, and is considerably cheaper than protein from other more conventional protein sources.

The results of this project showed that the bio-degradability of a cellulosic waste could be increased markedly by an economical treatment process on a continuous basis, and that the treated cellulosic could be used as the sole carbon substrate for celluloytic microorganisms. The organisms used in this study demonstrated rapid growth rates and generally accepted carbohydrate to protein transfer efficiencies. The cell product had a good amino acid pattern, contained over 50% crude protein, and was nontoxic to rats when fed in amounts up to 75% of their diet.

Economic analyses indicate that single-cell-protein of good quality could be produced at a cost of about 6.7¢ per pound. This cost would allow the cellulose-produced SCP to compete very favorably in the market with almost any protein source available.

With the future need for more usable cellulose fiber encouraging the use of bagasse, a considerable and increasing production of heretofore waste pith will result. The even more critical demand for food, especially protein, should bolster the economic possibility of the microbial production of single-cell-protein from either whole bagasse, or preferable, bagasse pith. The ready availability of pith either at the sugar or pulp mill solves the problem of gathering, and the expansion of the mill to include a fermentation unit could not only result in a credit from pith use, but also serve as a significant economic input to the mill.

There are several other processes currently in planning stages at LSU that could, if successful, give even greater diversification to the microbial unit. Some of the possibilities are the use of the unit as an enzymatic de-pithing process, the production of enzymes and specialty chemicals by the unit, and the up-grading of cellulosics for use as feed material to chemical processing units.

We are, at the moment, in the midst of constructing a new fermentation pilot unit facility at the NASA Mississippi Test Facility. This unit include equipment for a continuous chemical treatment, and continuous fermentation and harvesting. We will have a 150 gallon fermenter with extensive recording and control equipment, and a treatment and sterilization unit flexible enough for treatment of almost any cellulosic waste. The facility should be finished in September, and we hope then to obtain the funding, manpower, and time to investigate further uses of this process.

REFERENCES

Atchison, J. E., (1968), "Some Economic Factors Involved in the Utilization of Bagasse for the Manufacture of Pulp and Paper," paper presented at the 13th Congress, International Society of Sugar Cane Technologists, March 2-16, 1968.

Baumgardt, B. R., *et, al.*, (1962), *J. of Dairy Science*, 45, 62.

Callihan, C. D., and C. E. Dunlap, (1968), "The Economics of Microbial Proteins Produced from Cellulosic Wastes," presented at A.I.Ch.E meeting at Los Angeles, December.

Hajny, G. J., C. H. Gardner, and G. J. Ritter, (1951), *Ind. and Engr. Chem.*, *43*, 6, 1384.

Han, Y. W., and V. R. Srinivasan, (1968), *Applied Microbiology*, *16*, 8, 1140.

Keys, J. E., and P. J. Van Soest, (1967), paper presented at ADSA National Meeting, Ithaca, New York.

King, Norman, (1968), personal communication.

Quicke, G. V. and O. G. Bentley, (1959), *J. Animal Sci.*, *18*, 365.

Siu, R. G. H. (1951, *Microbial Decomposition of Cellulose*, Reinhold Publishing Corporation, New York, New York.

CONTINUOUS CRYSTALLIZERON OPERATION

AT LULA FACTORY

Patrick E. Cancienne, Belle Rose, La.

We began using continous crystallizers for low grade massecuites at Lula Factory in 1967, so we have now completed two seasons of operation with this system.

In figure 1, on page 2, is a schematic of our crystallization installation that was used for the batch system. I am sure it is very similar to most sugar factory installations. We have nine crystallizers of 1200 cubic feet capacity with Dyer Blanchard coils rotating at one revolution per minute. It has a trough to discharge the massecuite from the pans, with a variety of gates to direct the flow to any crystallizer desired. There are the numerous water valves that regulate hot or cold water to the rotating coils and, a valve at the bottom of each unit to discharge the massecuite into a trough to convey it to the magma pump.

Figure 2, on page 3, is a schematic showing the same batch system with the alterations converting it to the continuous operation.

A holding vessel (A) was constructed above the existing crystallizers for receiving the massecuite from the pans. From this holding vessel the massecuite is discharged by gravity to the No. 1 Crystallizer.

Gates were cut between each unit as shown for the massecuite to flow from one vessel to the next.

In the center of each crystallizer, we added a baffle with an opening at the bottom. This was to help prevent channeling of massecuite during the flow.

On the last unit, #9, we welded a large pipe from the bottom of the crystallizer to the suction of the pump. This gave a positive pressure on the suction of the magma pump and also kept the air from cooling the massecuite as it does in an open trough.

We boil our low grade strikes in a low head calandria pan which has a mechanical circulator and a capacity of 1200 cubic feet. Allowing for a little excess massecuite, we designed vessel A to hold 1300 cubic feet.

The pan operation usually produces five strikes each 24 hours; so, figuring these five strikes times their volume of 1200 cublic feet and dividing by the total number of minutes, we arrived at an approximate flow of 4 cubic feet per minute of massecuite through the crystallizers. Not knowing how much head would be needed as a pushing force for this massecuite flow, we made the discharge gates 30" wide by 30" deep on unit No. 1 and increased this 3" depth on each until the last, which is 30" wide by 51" deep. The area for massecuite flow under the baffles was slightly larger. All of these openings proved to be very ample as we noticed only 1" to 4" difference in elevation between units 1 and 9.

In operation we had cold water (50° to 70°) circulating through the revolving coils of the first two crystallizers only, units 1 & 2. The massecuite is cooled to a temperature between 95° and 105° F and remains close to this temperature until being reheated. There is no water at all circulating through units 3, 4, 5, 6 and 7. Hot water (150° to 155° F) was fed into the coils of units 8 and 9. The temperature of the massecuite leaving the crystallizer is between 115° and 125° F.

During the grinding operation, the sugar boiler controlled the valve discharging the massecuite from vessel A, and adjusted it according to the number

SCHEMATIC DIAGRAM OF THE BATCH CRYSTALLIZATION SYSTEM

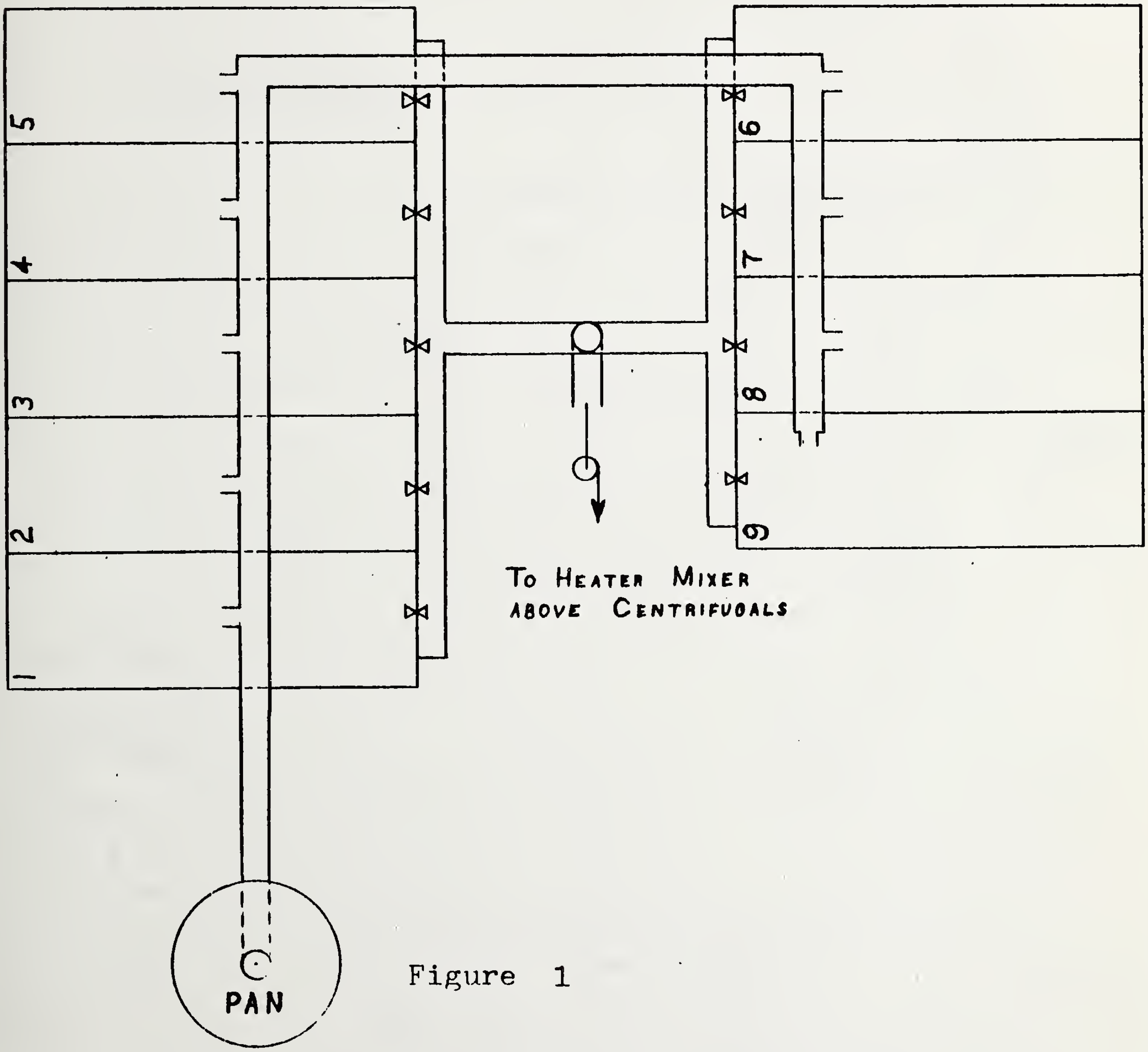

Figure 1

SCHEMATIC DIAGRAM OF THE CONTINUOUS CRYSTALLIZATION SYSTEM

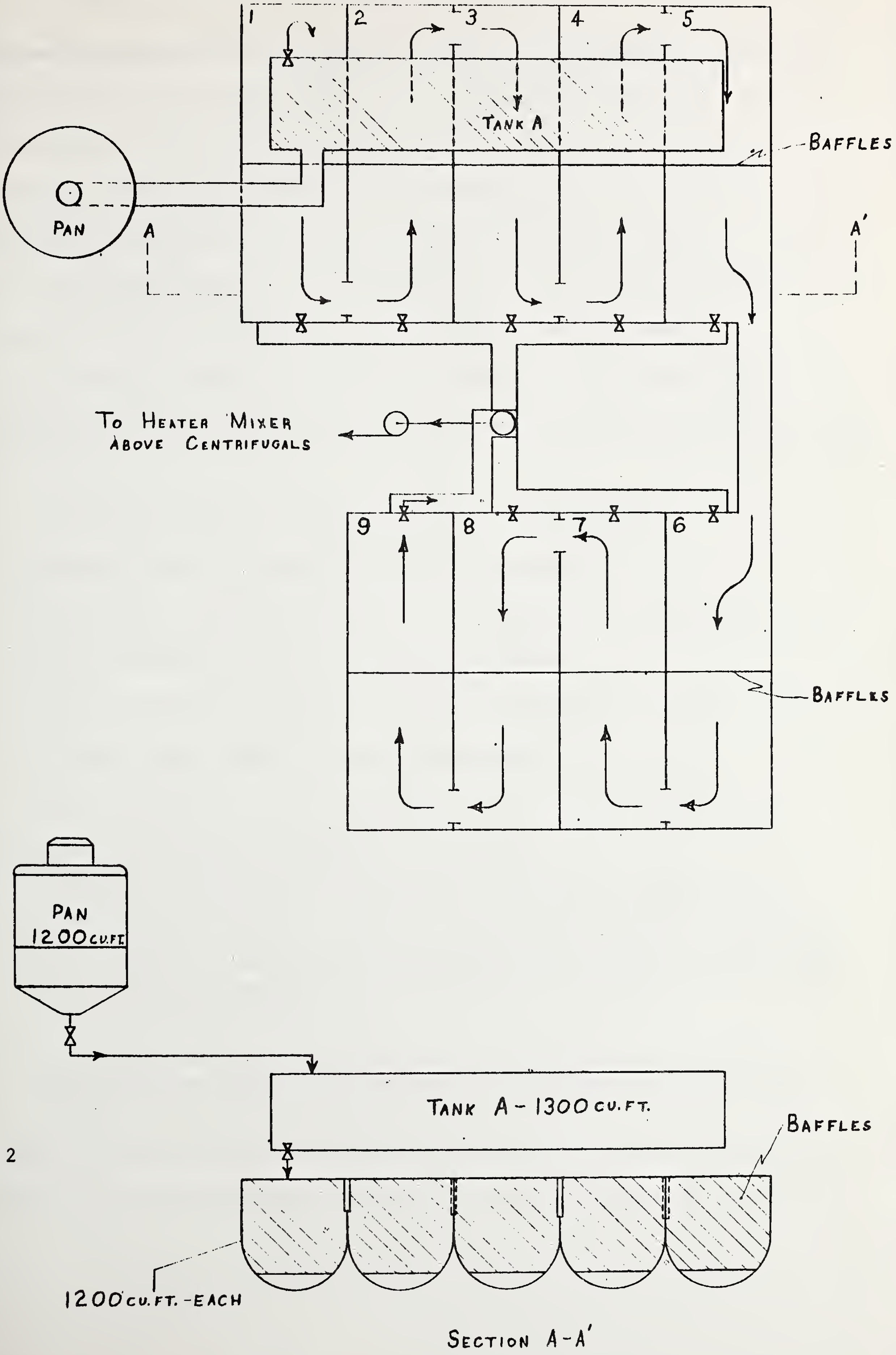

Figure 2

of strikes they made and another worker checked and regulated the magma pump. Other than these adjustments, there was no other attention we had to give to this operation.

Before going to this system our C' pan was detained 30 to 45 minutes when discharging to crystallizer units 6, 7, 8 and 9, because of the long trough in which this massecuite had to travel. Now it takes only 4 to 5 minutes for discharging all strikes, so our pans can be utilized more efficiently.

The continuous crystallizer system has worked out for us much better than we anticipated. Some of the advantages we have found from the continuous system are:

1. Massecuites from the crystallizers are more uniform.
2. Better control in heating and cooling massecuites.
3. Less labor involved (No water valves or massecuite valves to change).
4. More efficient use of all crystallizer units.
5. Easier to install equipment for adding chemicals to massecuite.
6. Better control with low grade centrifugals.
7. Have been able to drop all Massecuites at slightly higher brix.
8. More flexibility in dropping "C" strikes.
   Example: in the batch method, strike should contain the same volume as the crystallizer for maximum use of the unit, where as in the continuous process, the crystallizer could be kept full dropping any volume of "C" strikes. Also, if a factory has crystallizers holding 1200 cubic feet and used this system they could boil their low grades in a pan with a capacity less or more than this size and still keep all crystallizers full.
9. A factory could install crystallizers of varying sizes, and still boil the same quantity of low grade in each strike and yet utilize their crystallizers to maximum capacity.

The massecuite in each crystallizer was carried at a lower level than we carried it in the batch system. We kept ours about 20" below the top of the crystallizer. This gave us about 2400 cubic feet of emergency storage.

Unlike batch crystallizers, all the units are continously utilized and this procedure should serve as an initial step to future factory automation.

SUMMARY

ANNUAL MEETING
AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

February 6, 1969

The Annual Meeting of the American Society of Sugar Cane Technologists was held on Thursday, February 6, 1969, at the Bellemont Motor Hotel, Baton Rouge, Louisiana.

The meeting was called to order by President Clay Terry. After a few opening remarks he presented Mr. Preston H. Dunckelman, Chairman of the Agricultural Section, who introduced the following program:

The Development and Use of the United States Sugar Corporation Mechanical Cane Harvester	Joe P. Sexton United States Sugar Corporation
The Effects of Pesticides on Non-Target Organisms	Dr. Dale Newsom Louisiana State University Baton Rouge, Louisiana
The XIII Congress, ISSCT, Taiwan, 1968	Dr. Denver T. Loupe Cooperative Extension Service Baton Rouge, Louisiana
	E. R. Stamper Louisiana State University Baton Rouge, Louisiana
	Eugene Graugnard St. James, Louisiana

At the close of the session, Mr. Dunckelman presented certificates of appreciation from the Society to each of the participants.

There followed a Business Session. Items discussed, action taken, etc., are as follows:

1. A financial statement was presented by Denver T. Loupe, Secretary-Treasurer and approved as distributed.

2. President Terry called for a moment of silent prayer for deceased A.S.S.C.T. members. Those listed were: Arthur Keller, T. J. Stafford and A. J. Isaacks.

3. Approval was granted to President Terry to appoint a committee (in consultation with in-coming President) to study the feasibility of our Society publishing a "Technical Supplement" to our proceedings. The committee to make recommendations to the membership at the next summer meeting.

4. The president was authorized to appoint a committee to study the matter of increasing the active participation of our Society of members from Florida, including the possibility of meetings outside Louisiana.

5. Denver Loupe, acting for Minus Granger, Chairman of the Honorary Membership Committee, presented the following names for election to Honorary Membership:

a. Dr. George Arceneaux

b. P. J. deGravelles, Sr.

Approved. Members of the committee included Larry Lampo and Robert Allain.

The meeting was recessed for lunch. At 2:00 p.m., President Terry convened the afternoon session. He presented Frank Barker, who presided in the absence of Dr. John Seip, Chairman of the Manufacturing Section who presented the following program:

Burning Bagasse	Victor J. Baillet Caldwell Sugar Cooperative, Inc. Thibodaux, Louisiana
Full Pan Seeding of Low Grade Strikes -- A Brief Review	T. R. Ray T. R. Ray, Inc. Baton Rouge, Louisiana

Handling of Cane Muds in the Eimco Belt Filter	James R. Stembridge Eimco Corporation Salt Lake City, Utah
Progress Report on the Recent Development in Raw Sugar Processing in Louisiana	Dr. Philippe Strich Suchem Ponce, Puerto Rico

Acting Chairman Barker presented each participant a certificate in appreciation for the presentation.

Following several announcements the meeting was adjourned.

The Annual Banquet got underway at 6:45 p.m. Invocation was given by Mr. F. A. Graugnard, Jr.

Mayor Woodrow W. Dumas welcomed in a very pleasant manner the Society members to Baton Rouge, He presented a "Key" to the city to Irvin A. Hoff, the guest speaker.

Members at the head table were presented. Although past presidents were not seated at a special table, all present were recognized.

President Terry presented a membership certificate to each of the Honorary members elected during the business session; namely, Dr. George Arceneaux and P. J. deGravelles, Sr.

The guest speaker was introduced by President Terry. He was Mr. Irvin A. Hoff, President, U. S. Cane Sugar Refiners Association, who spoke on U. S. sugar problems.

Special guests were recognized.

The following officers for 1969 were presented:

J. A. "Pete" Dornier, Jr. -- President
Minus J. Granger -- 1st Vice-President
F. A. Graugnard, Jr. -- 2nd Vice-President
Denver T. Loupe -- Secretary-Treasurer
James Irvine -- Chairman, Agricultural Section

Ramon Billeaud -- Chairman, Manufacturing Section
Charles Savoie -- Chairman-At-Large
Clay Terry -- Immediate Past-President

In accepting the presidency for 1969, Mr. Dornier pledged continued efforts toward the improvement of our A.S.S.C.T. Following presentation of a suitably inscribed gavel to Past-President Terry, the Banquet was adjourned.

Respectfully submitted,

Denver T. Loupe
Denver T. Loupe
Secretary-Treasurer

DTL:mkb

SUMMARY

MINUTES OF THE SUMMER MEETING

Thibodaux, Louisiana
June 5, 1969

The Summer Meeting of the American Society of Sugarcane Technologists was held in Peltier Auditorium, Francis T. Nicholls State College, Thibodaux, Louisiana on Thursday, June 5, 1969. The meeting was called to order by President J. A. "Pete" Dornier, Jr. at 9:15 a.m.

Following brief introductory remarks and announcements, the Society was "welcomed" to Thibodaux by Mayor Warren Harang, Jr. Dr. Donald Ayo, on behalf of Dr. Vernon Galliano, President of Nicholls State College, brought greetings from the College Staff and assured us of their cooperation.

President Dornier introduced Dr. James Irvine, Chairman of the Agricultural Section who presented the following program:

"The Current Status of Sugarcane Insect Control in Louisiana" by Dr. Sess Hensley, Louisiana State University, Baton Rouge, Louisiana and "Sugarcane Mosaic in Louisiana: Some Aspects of a Chronic Problem" by Dr. G. T. A. Benda, U.S.D.A. Sugarcane Station, Houma, Louisiana.

The Agricultural Section concluded with the presentation of certificates of appreciation to the participants by Dr. Irvine.

A coffee break, was followed by the introduction of Mr. Ramon Billeaud, Chairman of the Manufacturing Section. The following program was presented:

"Microbial Protein Production From Sugarcane Bagasse" by Dr. Charles Dunlap, Louisiana State University, Baton Rouge, Louisiana and "Continuous Crystallizers" by Mr. Patrick E. Cancienne, Lula Factory, Belle Rose, Louisiana.

The Manufacturing Section concluded with the presentation of certificates of appreciation to participants by Mr. Billeaud.

A business session followed at which time the following items were discussed:

1) President Dornier reported that $1,000 had been deposited in savings as a result of Executive Committee action.

2) Announced that the next annual meeting was set for Thursday, February 5, 1970 at the Bellemont Motor Hotel, Baton Rouge, Louisiana.

3) A progress report concerning the XIV Congress, ISSCT was presented by Denver T. Loupe at which time he urged ASSCT members to become ISSCT members.

Following routine announcements the meeting was adjourned. Lunch was served at the V.F.W. Hall.

Respectfully submitted

Denver T. Loupe

Denver T. Loupe
Secretary-Treasurer

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PROCEEDINGS

American Society of Sugar Cane Technologists

Volume 17 - Papers for 1970

December, 1970

PROCEEDINGS

American Society of Sugar Cane Technologists

Volume 17 - Papers for 1970

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FOREWORD

This is the seventeenth volume of Proceedings of the Society which has been published since its founding in 1938.

The first volume published in 1941 included papers presented during 1938, 1939, and 1940. Mr. Walter Godchaux, Jr., the then Secretary-Treasurer, edited that edition.

The second volume published in 1946 included papers presented during 1941-1945 inclusive. Dr. E. V. Abbott, Secretary-Treasurer, edited that edition.

The third volume published in 1953 included papers presented during 1946-1950 inclusive. A fourth volume was published in 1955 and presented papers for the years 1950 through 1953. Volume five contains papers for the years 1954 and 1955. The sixth volume included papers presented during 1956. The third through the sixth volumes were edited by Dr. Arthur G. Keller.

The seventh volume, which is in two parts, 7A and 7B, contains papers presented during 1957 through 1960 inclusive. The eighth through the fifteenth volumes contain papers presented during 1961 through 1969, respectively. These volumes, as well as this, the seventeenth volume, which includes papers for the year 1970, have been compiled by the writer.

Denver T. Loupe
Denver T. Loupe
Secretary-Treasurer

December, 1970

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Sweet Sorghum for Sugar Production

by R. E. Coleman [1]

Introduction

Sweet sorghum was introduced into the United States more than 100 years ago as a potential sugar crop. At that time about 20 high sugar (sucrose) varieties were introduced from the Natal region of South Africa. Dr. H. W. Wiley, Head, Division of Chemistry, U.S. Department of Agriculture, experimented with these varieties during the late 1800's evaluating their potential use for the manufacture of crystalized sugar (5). The varieties were highly susceptible to diseases. Research on sweet sorghum for sugar ceased about 1890 owing to the limited knowledge about processing procedures for the new crop and the absence of breeding research to produce improved disease-resistant varieties.

The U. S. Department of Agriculture resumed research with sweet sorghum in 1938 on a limited scale at Meridian, Mississippi. In 1941 funds were appropriated for additional research of the crop (1). During World War II interest in the crop for sugar production increased when the importation of sugar was restricted. The early imported varieties and new varieties developed by hybridization for sirup and feed were evaluated for growth capacity, disease resistance, and sugar content. During the 1940's other varieties were imported from Africa, India, South Africa, and other countries for evaluation (1). Sorghum importations have continued over the years until we now have assembled at Meridian, Mississippi more than 4,000 lines of valuable genetic material. Many of these importations have desirable characters for sugar production, superior vigor, disease resistance, and high sucrose content. Since 1938 breeding research carried out by USDA scientists to develop commercial type varieties having high qualities for sirup or sugar production has made good progress (1). As a result of this breeding effort, five new high-yielding, disease-resistant varieties of sweet sorghum have become available to American farmers--Sart, Tracy, Wiley, Brawley, and Rio. Two of these, Brawley and Rio, have a potential for sugar production.

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[1] Leader, Sugarcane and Sweet Sorghum Investigations, Tobacco and Sugar Crops Research Branch, Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, MD.

The U. S. Department of Agriculture chemists carried out new research at Meridian, Mississippi, during the early 1940's on processing the crop for sugar Although they were able to crystalize sugar in laboratory amounts, the research revealed two components of the juice, starch and aconitic acid, which were deterrants to sugar crystalization (4). Significant progress was made in developing methods for removing these components of the juice. However, the varieties available at the time were still susceptible to diseases, and consequently their productive capacity was low. About the same time two of the sweet sorghum varieties introduced earlier, Collier and Rex, were found to have genetic capability for growth and production of sugar despite the ravaging effects of diseases. These varieties were the progenitors of superior new varieties that inherited disease resistance from imported tropical parental lines that did not possess good growth capabilities and high sugar content. A cross was made between the disease susceptible, high sucrose variety, Rex, and the disease-resistant variety, MN 1048, imported from Equatorial Africa. This cross resulted in the new variety, Rio. Rio is resistant to most sweet sorghum diseases; it grows satisfactorily under a wide range of conditions, and has a high sucrose content (2). Another variety which has some potential as a sugar variety is Brawley. This originated from a cross between a selection from Rex that possessed some lodging resistance and a selection from the white-seeded Collier variety which had a high sucrose content as well as lodging resistance. The variety, Brawley, has shown the greatest potential as a crop for the Imperial

Valley of California. USDA scientists are developing even better disease-resistant, high sucrose varieties. Many of these are in the advanced nursery and replicated yield trials at several locations in Louisiana, Mississippi, and Texas. We have good reason to believe that future breeding research will produce varieties that would make sweet sorghum a potential crop for sugar production in several Southeastern States.

Our research shows that sweet sorghum can be grown successfully under a wide range of cultural conditions in more than 20 States. High sucrose varieties, now available, produce ripe seed and can be harvested in 115-120 days. Experience with growing sweet sorghum as a sugar crop enables us to discuss some of the problems involved in producing the crop. Among important factors for sugar production are varieties, cultural practices, insect and disease problems, and harvesting.

Factors in the Production of Sweet Sorghum

Sweet sorghum is grown for sirup production or for feed in Mississippi and many other Southern States. As a result of our research program on sweet sorghum for sirup, we are familiar with the general practices used in producing the crop and the several factors which are important in growing the crop. These factors are of the same importance when the crop is grown for sugar production.

Varieties: There are two varieties, Rio and Brawley, high enough in sugar content and productive enough to be adequate for sugar production. Brawley, susceptible to most diseases of the crop, is therefore adaptable only to dry areas of southern California and other States (6). Rio, resistant to most diseases, is adapted to both dry areas and humid regions of the Southeastern States, and as stated, breeding research is producing improved varieties. Comparative yields between Brawley and Rio in California and Texas are shown in Table 1.

Yields of sweet sorghum are dependent upon the region in which they are grown. High yields of stalks in sugar per acre would be essential for economical production of sugar from the crop. Rio produces from 10-20 tons of millable stalks per acre in the Southeastern States under favorable conditions. Sirup varieties such as Sart and Wiley produce 25-30 tons under the same conditions.

For sugar production sucrose in the juice of sweet sorghum should be high, between 14.0 and 16 0 percent. Purity of the juice should be 70 percent or higher. Percentage of invert sugars should be less than 5 percent of the solids. When the percentage of invert sugars is high, there is a loss in recoverable sugar (sucrose). In 1966 the average yield for Rio sweet sorghum in Mississippi, Louisiana, Texas, and California is shown in Table 2.

Starch and aconitic acid content of the juice should be low; however, both components are removed in the manufacturing process. Inversion of sucrose during the period between harvesting and processing should be at a low level. A high rate of inversion reduces the amount of recoverable sugar. Loss of sugar by inversion of sucrose to other forms of sugar (carbohydrates), during the period between harvesting and processing, may under some conditions have an important influence on the economy of the crop. This is a greater factor in production of sweet sorghum than in the production of the present varieties of sugarcane. Varieties differ greatly in the rate of inversion of sucrose after harvesting. Growth conditions prior to harvest may influence the rate of inversion; temperature and moisture conditions at the time of, and immediately following harvest, have a pronounced effect on inversion of sucrose. It is apparrent that sweet sorghum should be milled within 24 hours after cutting.

Juiciness is an important varietal character for sugar production. Sucrose is removed from the stalks in the milling process as a component of the juice. A high percentage of juice is therefore a primary component for maximum sugar recovery.

As with sugarcane, lodging of sweet sorghum has a significant influence on quality of juice for sugar production. There is no significant improvement in sugar content after stalks lodge. If harvesting is not done promptly after lodging, there may be a reduction of quality. In sweet sorghum, maturity is associated with the development of the seedhead, in contrast with the maturing of sugarcane which is associated with cessation of vegetarial growth. Therefore, maturity can be influenced to a certain extent by date of planting. In general the plant produces a seedhead in a fixed number of days, approximately 115-120. Once the seedhead has reached what is called the ripe, or hard dough, stage, sucrose content is at its maximum. Under most field conditions plants will maintain their sucrose content for about 1 month after reaching the stage. This means that the plants could be harvested anytime during the 1-month period without significant loss in sugar.

Another factor of some importance is seed germination. Seed of some varieties germinate poorly. Poor germination is associated with cracks in the seed coat or other abnormalities of the seed. Good germination is a prerequisite to the even stands required for maximum yield, uniform maturity, and high sugar content. As with sugarcane, germination is also influenced by seedbed preparation.

Diseases: Diseases are an important factor in sweet sorghum production (3). Eventhough varieties have been developed that are highly resistant to diseases, varieties that have high resistance to one disease may be susceptible to other diseases. Mosaic has been a minor disease of sweet sorghum, although during recent years it has been observed occasionally in Mississippi, Georgia, Kentucky, and Texas. Rust is a common disease in most humid areas of the South. Anthracnose, zonate leaf spot, and other leaf diseases develop readily on susceptible varieties. Downy mildew has become an important disease in parts of Texas.

Insects: The sweet sorghum crop is an attractive host for several types of insects, and the control of these insects is an important factor in the growth of the crop (3). The greatest damage in recent years has been caused by borers. In many areas the Lesser corn stalk borer causes damage to young plants and mature stalks. In some areas the sugarcane borer, the Southwestern corn borer, *Chilo loftini*, and White grub (*Phyllophaga crinita* and *P. submucida*) cause severe damage to plants of all ages. Another group of insects includes Wireworms, Sugarcane beetle, and White-fringed beetle, all less serious in terms of infestation but to be reckoned with in the growth of the crop. Other types of insects including aphids and cutworms may damage sweet sorghum plants under some conditions. Limited tests in Louisiana in the past few years indicate a need for control of the sugarcane borer in most areas.

Harvesting: Sweet sorghum will have to be harvested mechanically for economical sugar production. Some mechanical harvesters used for harvesting sugarcane, and those used for harvesting forage, may be adapted for harvesting sweet sorghum. Removal of the leaves, leaf sheaths, and seedheads would require special adjustments in harvesting equipment. Limited information collected at Meridian, Miss., indicates that the crop can be harvested by cutting the stalks into shorter lengths in the field, if the cut material is promptly moved to the factory for processing. Cutting the stalks into shorter lengths loosens and separates a good percentage of the trash material.

Cultural Practices: The seedbed preparation is just as important a factor in obtaining good germination with sweet sorghum than it is with sugarcane. The seedbed should be well firmed before planting. Poorly drained soil should not be used for the crop. Planting should be done after the soil is warm, usually April and later. Studies conducted in several areas indicate that the planting date may vary between April 1 through June 30 for optimum yields. The planting rate should provide a stand of one plant every 6 to 8 inches, and rows should be spaced approximately 40 inches apart, or plants can be placed in hills 16 to 24 inches apart to obtain maximum yields. Preliminary experiments at the Houma station this past year indicate that closer spacing than four plants every 24 inches did not increase yields. Thinning of the plant population by hand or mechanical means is not feasible. Adequate fertilization of the crop is more critical than it is for sugarcane, owing to the shorter growing period. Excessive amounts of available nitrogen decrease quality of the crop for sugar production. Applications of nitrogen should be limited to 40-60 pounds per acre under most conditions. Tests at the Houma Station last year indicated no increases in yields with applications of fertilizer in excess of 40 pounds of nitrogen.

Weed control is essential to the growth of sweet sorghum as it is with sugarcane, although the shorter growth period somewhat simplifies the problems. Broadleaf and grassy types of leaves need to be controlled. Propazine and other herbicides have been used experimentally for controlling small seeded annual broadleaf and grass weeds in sweet sorghum in Mississippi and Texas.

This brief review of the agricultural conditions essential for the production of sweet sorghum indicates that the crop is potentially useful as a supplimentary or alternate crop in specific areas in Mississippi and Louisiana, Texas and California. Development of new varieties through breeding can extend successful culture of the crop to other areas.

Acknowledgment

Information summarized in this report was furnished by Dr. I. E. Stokes, Collaborator, Tobacco and Sugar Crops Research Branch, Crops Research Division, U.S. Department of Agriculture.

Literature Cited

(1) Brandes, E.W., Progress with Sugar Sorgo, USDA Yearbook pp. 344-352, 1943-47.

(2) Coleman, O.H., et al. Rio, A new Disease-Resistant Variety of Sweet Sorghum for Southern United States. ARS 34-72, 1965.

(3) Stokes, I.E., et al. Culture of Sorgo for Sirup Production USDA Farmer's Bulletin 2100, 1957.

(4) Ventre, E.K., and H.S. Paine. Making Sugar out of Sorgo. Seed World, Vol. 53, No. 6, March 1943.

(5) Wiley, H.W. Record of Experiments with Sorghum in 1893. USDA Bulletin 40, 1893.

(6) Anon. New High-Sugar Sorgo Variety Developed for Irrigated Areas. USDA Press Release 1063-58, 1958.

Table 1 Comparison of Yields of Brawley and Rio in 1966

Locations and Varieties	Yields of stalks per acre	Brix	Sucrose	Purity	Yields of sugar per ton of stalks	Yields of sugar Per acre
	Tons	degrees	%	%	lbs.	lbs.
California						
Reugger Farms						
Brawley	20.1	19.0	14.9	78.2	201.0	4040
Rio	21.7	22.1	15.4	69.8	193.9	4208
Texas						
Lubbock						
Brawley	12.3	18.7	15.8	84.5	230.3	2833
Rio	18.1	18.4	15.7	85.0	228.0	4127

Table 2 Yields of Rio Sweet Sorghum in 1966

Locations	Yields of Stalks per acre	Brix	Sucrose	Purity	Yields of Sugar Per ton of stalks	Yields of Sugar Per acre
	Tons	degrees	%	%	Lbs.	Lbs.
Louisiana						
Baton Rouge	17.5	18.4	12.9	70.1	167.2	2926
Mississippi						
Lorman	11.9	19.3	15.2	78.7	211.8	2520
Meridian	16.9	19.2	15.2	78.8	211.9	3581
State College	17.4	19.1	14.6	76.8	200.5	3489
Stoneville	20.9	22.4	16.0	71.6	210.3	4395
Average	16.8	20.0	15.2	76.5	208.6	3496
Texas						
Lubbock	18.1	18.4	15.7	85.0	228.0	4127
Weslaco	17.3	17.2	11.6	67.6	147.0	2543
Average	17.7	17.8	13.6	76.3	187.5	3335
California						
Reugger Farms	21.7	22.1	15.4	69.8	193.9	4208

WATER MANAGEMENT IN SUGARCANE PRODUCTION[1]

Cade E. Carter, Charles B. Elkins, and Jesse M. Floyd[2]

Presented at the American Society of Sugarcane Technologists
Meeting, February 1970, in Baton Rouge, Louisiana

Alluvial Mississippi River Delta soils and a semitropical climate provide reasonably favorable conditions for producing sugarcane in southeastern Louisiana. In 1969, slightly less than 300,000 acres of land were planted to sugarcane and yielded an average of 24.1 tons of cane per acre. Although yields have varied somewhat from year to year, they have gradually increased during the past 50 years (1919-1969). As shown in Figure 1, yields during this 50-year period have ranged from a low of 7 tons per acre in 1926 to a high of 29 tons per acre in 1963[3]. Improved field drainage, improved sugarcane varieties, better weed and pest control, and improved fertilizer programs all contribute to this overall increase. Further economical increases would certainly be welcomed by cane farmers. At the present price of cane ($9 per ton) and with an acreage of approximately 300,000 acres, each 1-ton increase in the State's average yield

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[1] A contribution from the Southern Branch, Soil and Water Conservation Research Division, USDA, in cooperation with the Louisiana Agricultural Experiment Station.

[2] Agricultural Engineer, Baton Rouge, La.; Assistant to Southern Branch Chief, Athens, Georgia; and Agricultural Research Technician, Baton Rouge, Louisiana, respectively.

[3] United States Department of Agriculture, 1919-1969 Agricultural Statistics, Washington, D.C.

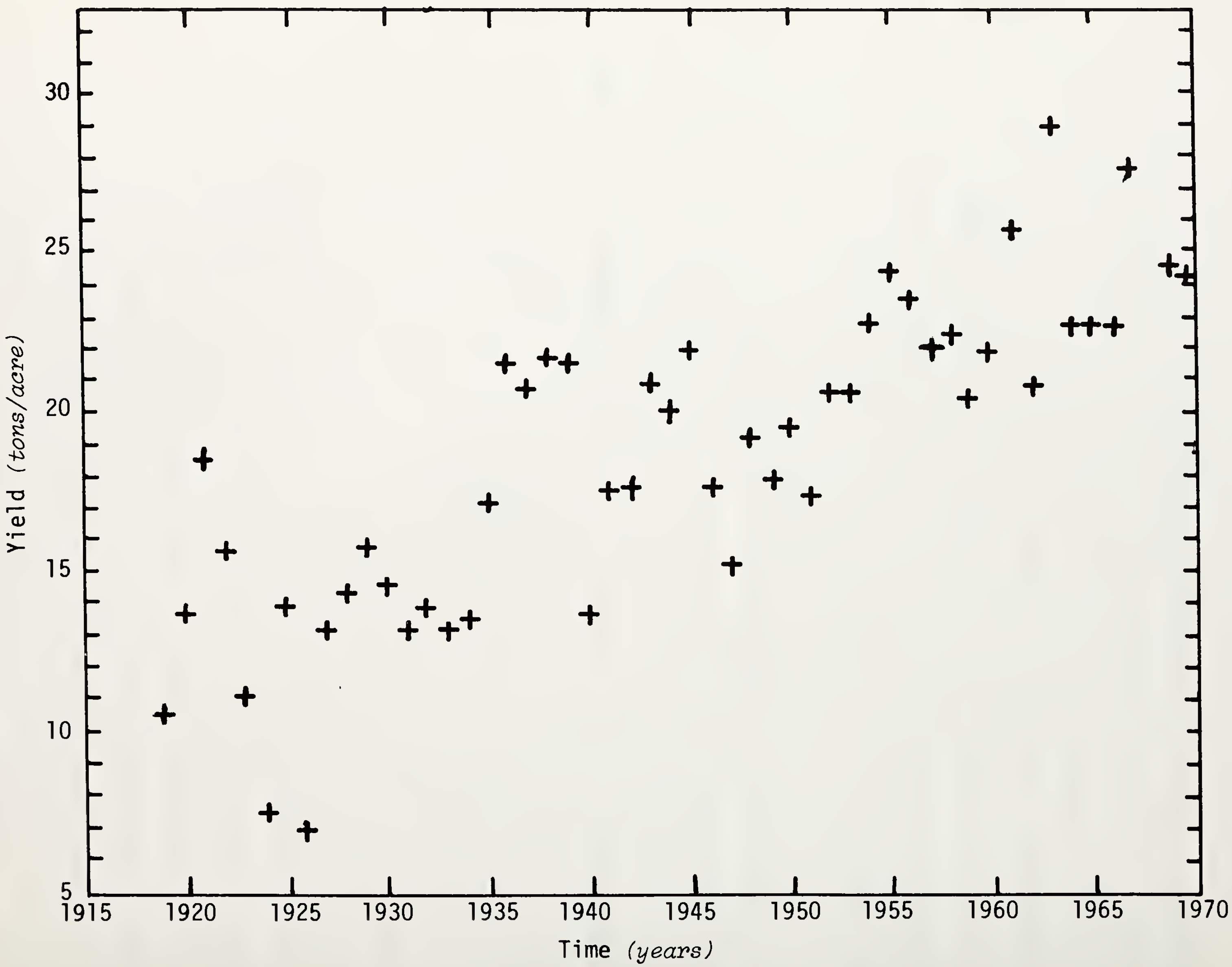

Figure 1. Louisiana State average cane yields from 1919 to 1969.

would increase the Louisiana cane farmer's gross income an additional 2.7 million dollars annually.

Normally cane yields decline sharply after the first ratoon crop. Increasing the longevity of cane at high-yield levels increases profits from cane production with little increase in cost. Most farmers depend on rainfall to supply their crops with water. This water source varies considerably both in amounts and time distribution. Annual rainfall in the sugarcane producing areas of Louisiana ranges from less than 40 inches to more than 85 inches[4]. Monthly rainfall varies from zero to more than 20 inches. Wide variations in water supplies such as these certainly affect sugarcane yield. Excesses as well as deficits in water supply inhibit cane growth and yields. Therefore managing soil water so that surplus water is removed during periods of excessive rainfall and water is supplied to the crop during drouth periods should improve the growth rate, yield, and longevity of sugarcane. This paper gives the results of an experiment, conducted jointly by USDA and LSU at Baton Rouge, Louisiana, in which soil water was managed in sugarcane during 1967, 1968, and 1969.

PROCEDURE

Twenty-four concrete-bordered plots, 0.01 acre in size, were established on LSU's Ben Hur Farm on Mhoon clay loam. The concrete borders began 1 foot under the soil surface and continued downward 4-1/2 feet. Each plot was equipped with tile drains connected by pipe to a sump where there was a water supply, valves, and a drain for maintaining the water level at any desired elevation from near the soil surface to 5-1/2 feet deep. The water elevation in each sump was adjusted to attain the desired water table elevation in the plots.

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[4] United States Department of Commerce 1919-1969 Climatological Data, Washington, D.C.

The 24 plots were planted in the fall of 1966 to CP 55-30 variety sugarcane in rows spaced 6 feet apart. Four water table treatments, 24, 32, 40, and 48 inches in depth, were imposed on 12 of these plots in the spring of 1967 to test the hypothesis that cane performance would be better with the intermediate water tables than with the shallower or the deeper depths. A treatment of uncontrolled water table as a check was not feasible at this site. Performance of cane on a nearby site with similar treatments except the water-table control was considered as a check. Also, yields were compared with average yields in the cane growing area.

Two treatments imposed on the other 12 plots in 1969 were 1) subsurface irrigation and 2) surface irrigation. In both cases, irrigation was started when 2/3 of the available water in the surface 2 feet of soil had been depleted. Soil water measurements made at weekly intervals and soil physical characteristics determined from representative samples of the Mhoon clay loam soil were used to determine when 2/3 of the available water had been depleted. Soil bulk densities of 1.37 and 1.53 gm/cm^3 for the 0- to 12-inch and 12- to 24-inch depths respectively, were measured. Soil water retention curves are shown in Figure 2. Soil water measurements were made using the neutron probe technique. When these data indicated that additional soil water was needed, it was added to the subsurface-irrigated plots by raising and maintaining the water in the control sumps until the soil in the connected plots approached saturation. The water level in the sump was then lowered to a depth of 5-1/2 feet and maintained at or below this depth until the next irrigation. This low water level permitted excess water to drain from the soil. Surface-irrigations were accomplished by ponding water in the row middles. Water in the sumps connected to these surface irrigated plots was kept at or below 5-1/2 feet to permit excess water to drain from the soil profile.

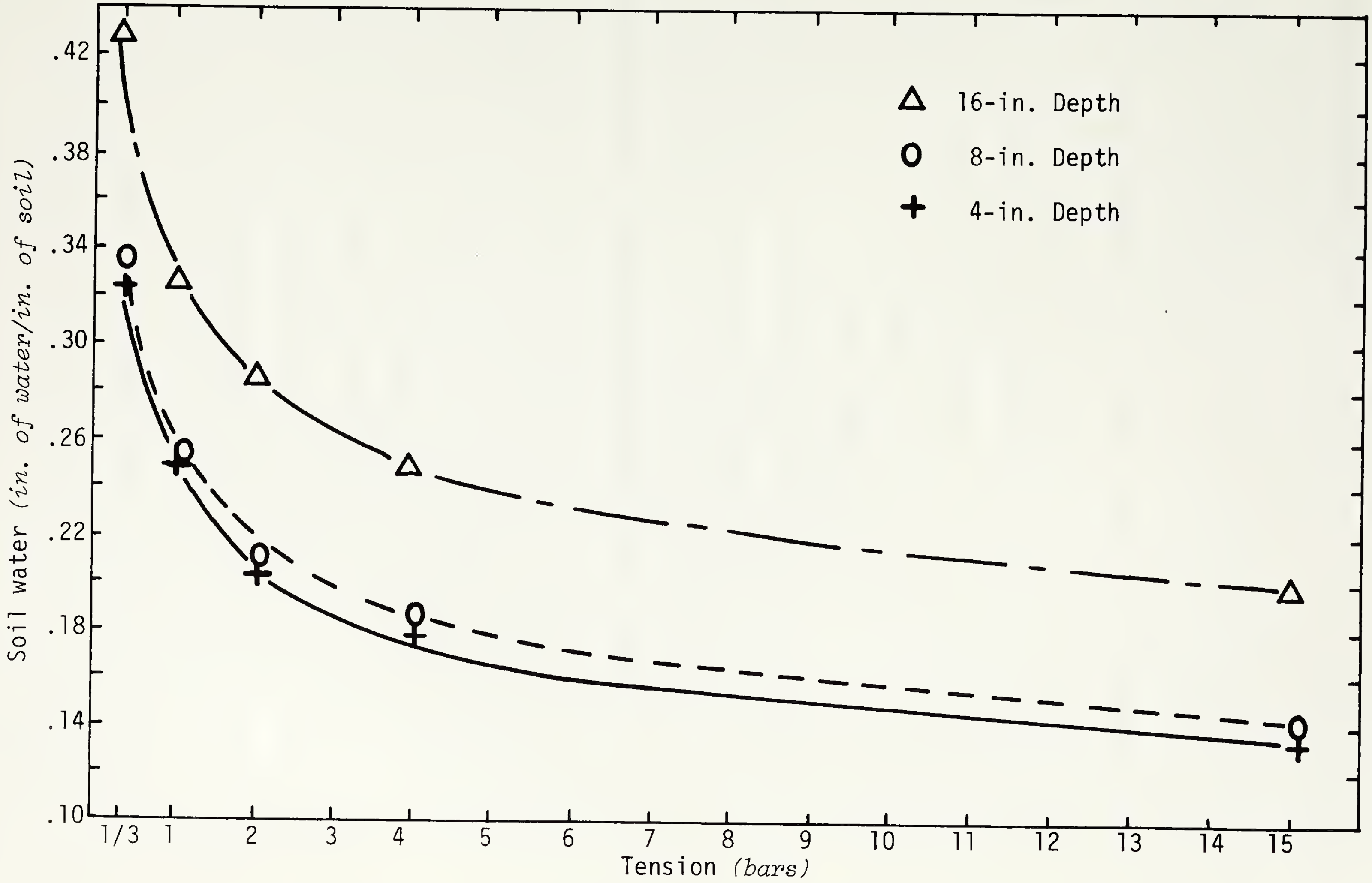

Figure 2. Soil water-tension relationship for Mhoon clay loam.

Except for water table treatments, conventional methods of cane culture were used. In the springs of 1967 and 1968, one application of fertilizer was made at rates of 100 lbs. N, 80 lbs. P_2O_5, and 80 lbs. K_2O per acre. In 1969, these rates were doubled, with half of the nitrogen fertilizer applied in the spring and the other half applied in the summer.

Cane was mechanically harvested during the first two weeks of November each year. After burning the leaves, the cane stalks were weighed. Ten-stalk samples were taken from each plot and analyzed at LSU's Botany-Plant Pathology Sugar Mill for sucrose, purity, and Brix density measure.

RESULTS

Soil Water Content

The four water table treatments that were imposed on 12 sugarcane plots caused various levels of water in the soil profile above the water tables. Data collected during the growing season of 1969 from the extreme water table treatments (24- and 48-inch) are shown in Figures 3 and 4. As indicated by these curves, the soil water at 8- and 16-inch depths below the soil surface was not significantly affected by treatment, but there were considerable differences at greater depths. Water content of the 32- and 40-inch water table treatments was between that from the two extreme treatments.

Only one year of irrigation data are available because the irrigation experiment was not initiated until 1969. This was an excellent year to test the value of irrigation in Louisiana because two drouth periods during the growing season resulted in the need to irrigate five different times. Only 1.12 inches of rain occurred, with the amount for a given rainstorm being usually 0.20 inch or less during the first drouth from May 18 until July 11. One 26-day period in June and early July had no measurable rainfall. Approxi-

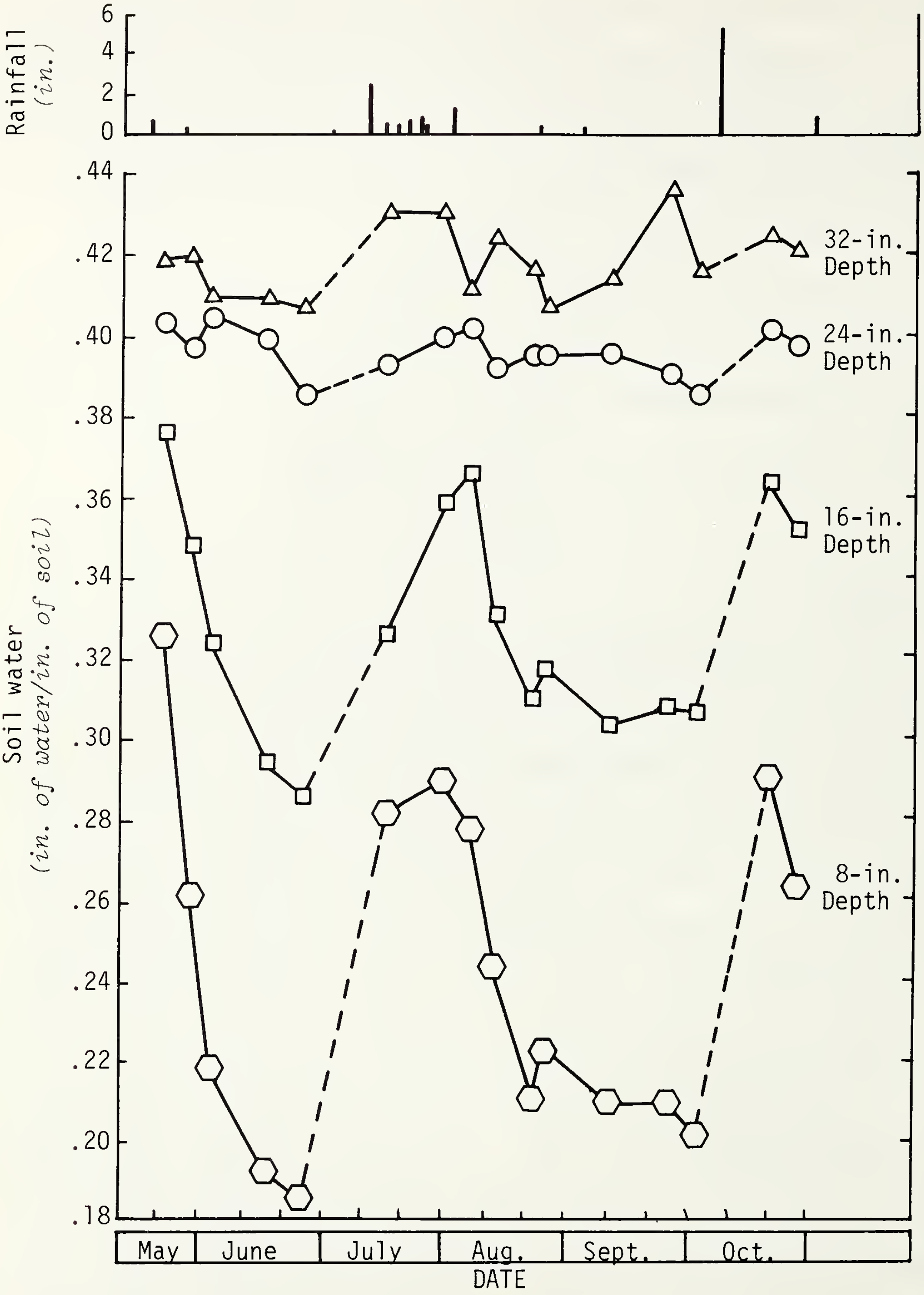

Figure 3. Rainfall data and soil water at various depths below the soil surface for plots with constant water table at 24 in. 1969.

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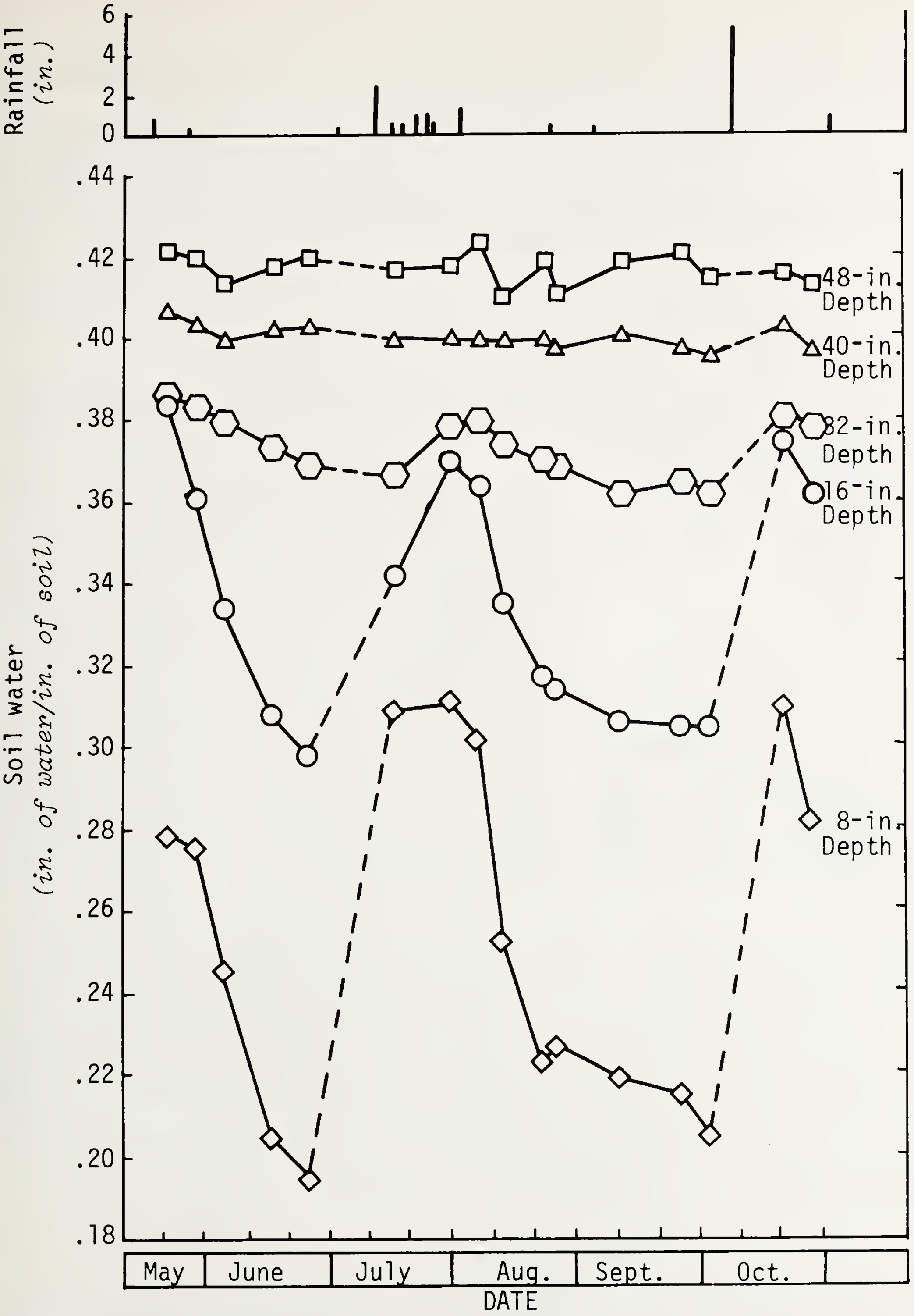

Figure 4. Rainfall data and soil water at various depths below the soil surface for plots with constant water table at 48 in. 1969.

mately 4 inches of water were applied on each of two occasions during this period. The other drouth period began after a 1.35-inch rain on August 3 and ended October 7 with a 5.30-inch rain. During the intervening time, light showers with amounts up to 0.37 inch occurred for a total rainfall of only 1.64 inch for this 65-day period. Approximately 4 inches of water were applied on each of three different occasions during this drouth period.

Soil water data collected during the growing season to determine the need for irrigations are shown in Figures 5 and 6 for the subsurface- and surface-irrigated plots, respectively. Also shown in these figures are rainfall data for storms .40 inch and greater and irrigation dates. The broken soil water lines in Figures 5 and 6 indicate a wetting cycle due either to rainfall or irrigation and represent only an approximate curve shape since sufficient data were not obtained in the interval to describe the curve shape exactly. The data in these two figures show that the soil water content of the two irrigation treatments was very nearly the same.

Yields

Yields recorded in Table 1 for the water-table study and in Table 2 for the irrigation study are in terms of net tons of cane per acre, sugar in tons per acre, per cent sucrose of the juice and the Brix density measure of total dissolved solids. Both the sucrose percentage and the Brix measure are factors in calculating standard tons from net tons of cane.

DISCUSSION

The sugarcane plants on these plots adapted readily to the various soil water regimes, since yields from each treatment were excellent from plant cane, first-year stubble, and second-year stubble. Data in Table 1 show that cane yields from the water-table treatments were above 40 net tons per acre

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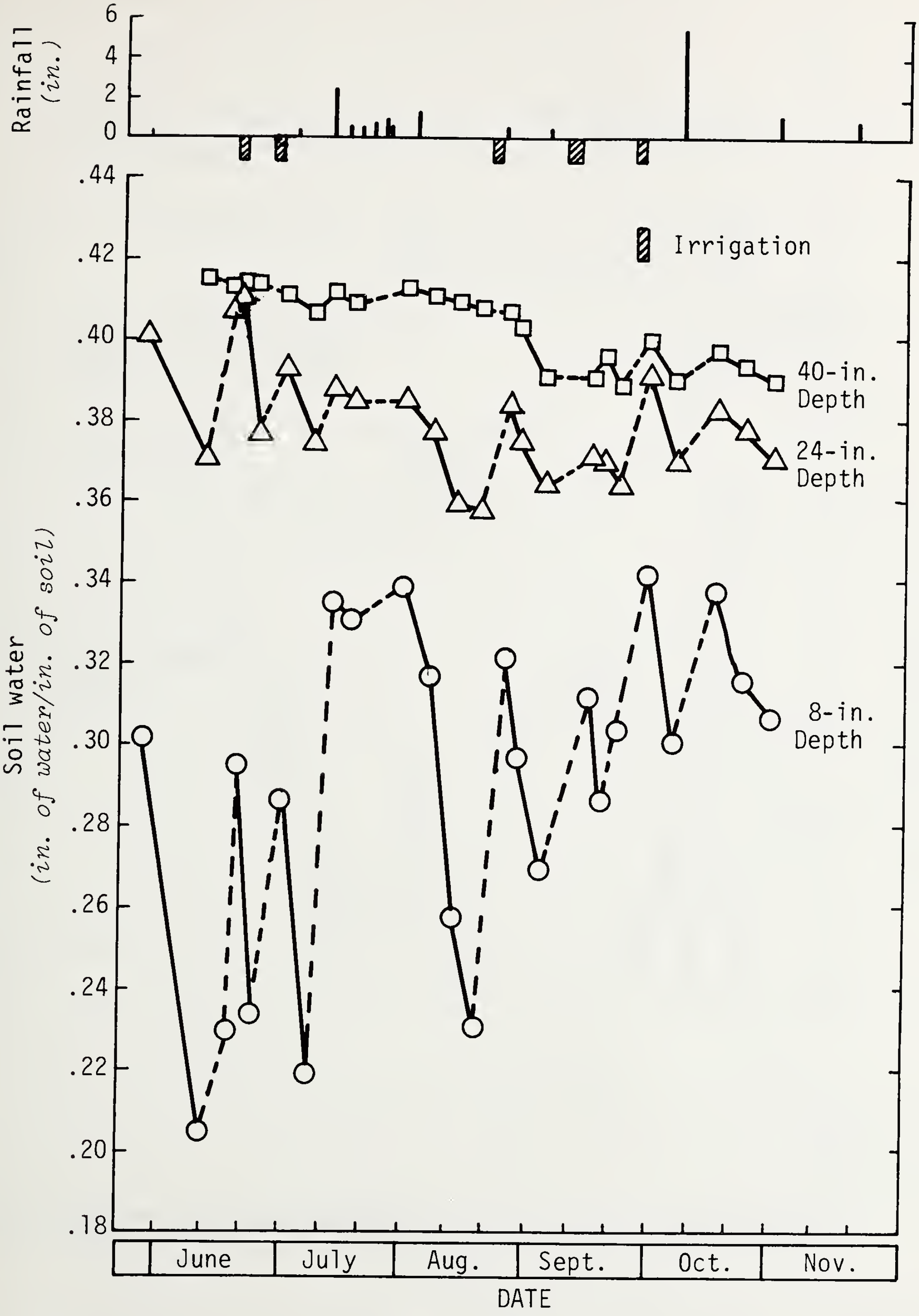

Figure 5. Soil water, irritation, and rainfall data for subsurface irrigated plots. 1969

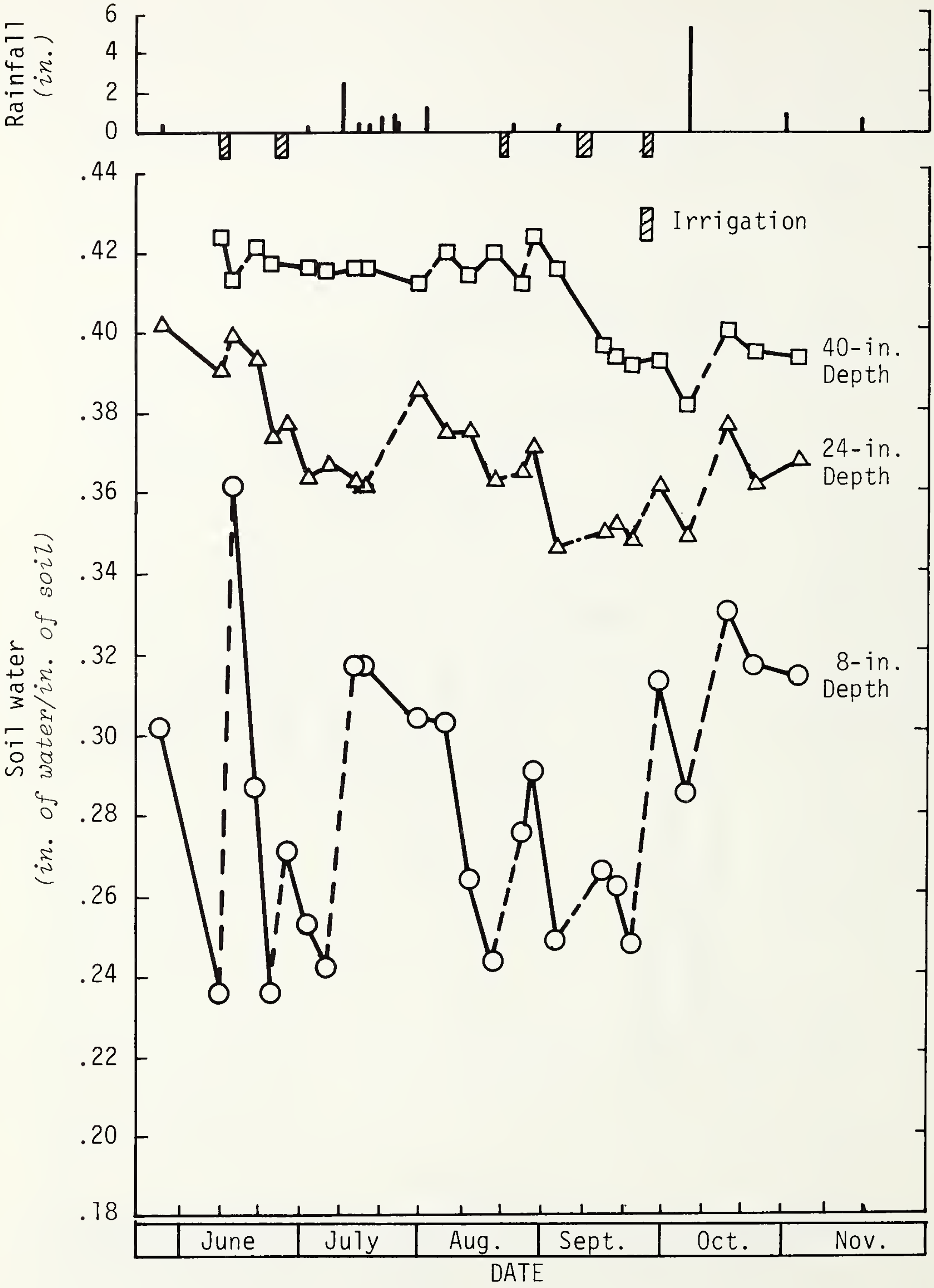

Figure 6. Soil water, irrigation, and rainfall data for surface irrigated plots. 1969

each of the three years of this experiment. These yields were significantly higher than Louisiana's State average of only 27.6, 26.1, and 24.1 net tons/acre during 1967, 1968, and 1969, respectively[5]. The high yields obtained from this experiment in 1969 -- second-year stubble -- are particularly significant, since cane yields normally decline considerably after first-year stubble.

The water table treatments apparently did not affect sucrose content or total solids of the cane juice. There was no statistical difference in cane yield, sucrose, or Brix among treatments.

The soil conditions created by the irrigation treatments apparently were favorable for sugarcane production since cane yields were higher than normal for 2nd year stubble. As shown in Table 2, yields were over 40 net tons per acre with only small differences in the two irrigation treatments. Yields from a second-year stubble check plot, which had no tile drains and was not irrigated, were only 26.6 net tons per acre, or near the State average. Yields from the irrigated plots were 63 percent higher than from the nonirrigated check plots. Data in Table 2 indicated that the nonirrigated cane had a higher sucrose content than did the irrigated cane. Even with this higher sucrose, the irrigation treatments still yielded considerably more sugar per acre than did the check plots.

Observations of the third-year stubble cane in the summer of 1970 indicated another high yielding crop. Cane is seldom held for third-year stubble under normal farm conditions.

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[5] The Sugar Bulletin, August 1969, Special Statistical Issue, Vol. 27, No. 22, p. 4.

Table 1. Yield and Juice Quality of Sugarcane with Various Depths to the Water Table

Depth To Water Table (*Inches*)	Year	Yield		Juice	
		Cane (*Net Tons/Acre*)	Sugar Content (*Tons/Acre*)	Sucrose (*Per Cent*)	Brix
24	1967	45.7	4.4	13.6	17.4
	1968	40.0	4.2	14.7	17.8
	1969	43.8	4.3	13.7	16.7
32	1967	49.7	4.7	13.4	17.3
	1968	40.6	4.3	14.8	17.8
	1969	46.7	4.4	13.5	16.5
40	1967	50.3	4.4	12.5	16.4
	1968	41.2	4.4	15.0	18.1
	1969	46.6	4.4	13.5	16.8
48	1967	47.0	4.2	12.8	16.7
	1968	42.8	4.5	14.7	17.8
	1969	48.9	4.7	13.3	16.5

Table 2. Juice Quality and Yield Data From Irrigation Treatments. Second Year Stubble, 1969.

			Yield	
Treatment	Sucrose	Brix	Cane	Sugar
	%		*Net tons/acre*	*Tons/acre*
Subsurface Irrigation	13.2	16.6	44.2	4.1
Surface Irrigation	13.7	16.8	42.6	4.1
Check	16.3	18.5	26.6	3.2

CONCLUSIONS

Water management treatments, which included constant water table, irrigation, and drainage, provided conditions favorable to sugarcane growth. Cane yields under constant water table treatments of 24, 32, 40, and 48 inch -depths were not significantly different and exceeded 40 net tons per acre for three consecutive years. Controlling water tables within these limits not only boosted cane yields considerably above the State average yields (which result from little or no water table control), but maintained these high yields in second-year stubble (and apparently into the third-year stubble), indicating a significant influence on the longevity of sugarcane. Surface or subsurface irrigation with subsurface drainage boosted second-year stubble yields to approximately 43 tons per acre, or 63 percent more than the cane plots that received no water management treatment. These findings suggest that drainage practices to control excess surface and subsurface water and irrigation to restore deficient soil water will increase annual yields and the longevity of cane.

APPLICATION OF JET AERATION
TO SUGAR CANE WASTE WATERS

George E. Wilson
Senior Research Engineer
Penberthy, a Division of Houdaille Industries
Prophetstown, Illinois

INTRODUCTION

As is the case for most of the chemical process industries, water is the largest single material entering the sugar cane mill, amounting to some 5000 gallons per ton of cane ground. (1) Most of this water entering the plant leaves in the form of a waste water having a five day, 20°C, biochemical oxygen demand (BOD_5) of from zero to 600 milligrams per liter (mg/l). (2) The bayous which receive this waste water have little or no net flow during the winter months of the mill's grind. Accordingly, their waste water assimilative capacity is very low considering that a typical mill will discharge some six million gallons per day to such receiving water.

The two primary types of waste water from the Louisiana sugar cane mill are the cane wash water and the condenser water. Table 1 indicates the primary pollutional characteristics of such (2) and the corresponding Louisiana Stream Control Commission (LSCC) regulatory requirements. (3) According to the Commission's 1955 order, cane wash water is to be impounded until the receiving waters are capable of assimilating it. However, condenser water flow rates are such that extended impoundment periods are impractical. In this case the 1955 order limits the entrainment BOD_5 of the condenser waters to 50 mg/l, or, to a value such that an acceptable fraction of the receiving water's saturated dissolved oxygen concentration is sustained. (4) In most cases this fraction is one-half.

In the case of Bayou Teche, during the 1967 grind, the dissolved oxygen concentration dipped below the desired 50 percent saturation concentration during most of the grind period. (5) In many cases septic conditions prevailed (Figure 1). Grab samples of condenser waters indicated that less than 25 per cent of the samples had BOD_5 values less than 50 mg/1 while more than 30 per cent had BOD_5 values in excess of 200 mg/1.

In many cases these high condenser water BOD_5 values due to entrainment could be reduced to acceptable levels by reducing the mill output to the grind rates for which it was designed. A realistic alternative for such a mill is a low cost and efficient waste water treatment facility which will reduce condenser water BOD_5 values to acceptable levels prior to discharge to receiving waters. This is particularly true in view of the present LSCC timetable calling for equivalent secondary treatment of waste water discharges by December, 1972. This paper considers some applications of such an alternative.

TABLE I

Sugarcane Waste Water Characteristics				
Source	Typical Flow Rates (gpm)	5-Day, 20°C Biochemical Oxygen Demand (BOD_5) (mg/1)	Suspended Solids	Louisiana Stream Control Commission (3, 4) Regulatory Requirements for Effluents (Bayou Teche)
Cane Wash Water	800-1200	200-600	1500-2500 (60% settleable)	Impound in compartmented impoundments providing approved sedimentation in first compartment for not less than 30 days prior to discharge; no discharge until BOD_5 has been satisfied and sufficient flow exists in receiving waters to assimilate BOD_5 residual.
Condenser Water	2000-6000	50-400	None	Effluent BOD_5 less than 50 mg/1 and such that a minimum 50 percent saturation dissolved oxygen concentration is maintained in the receiving water.

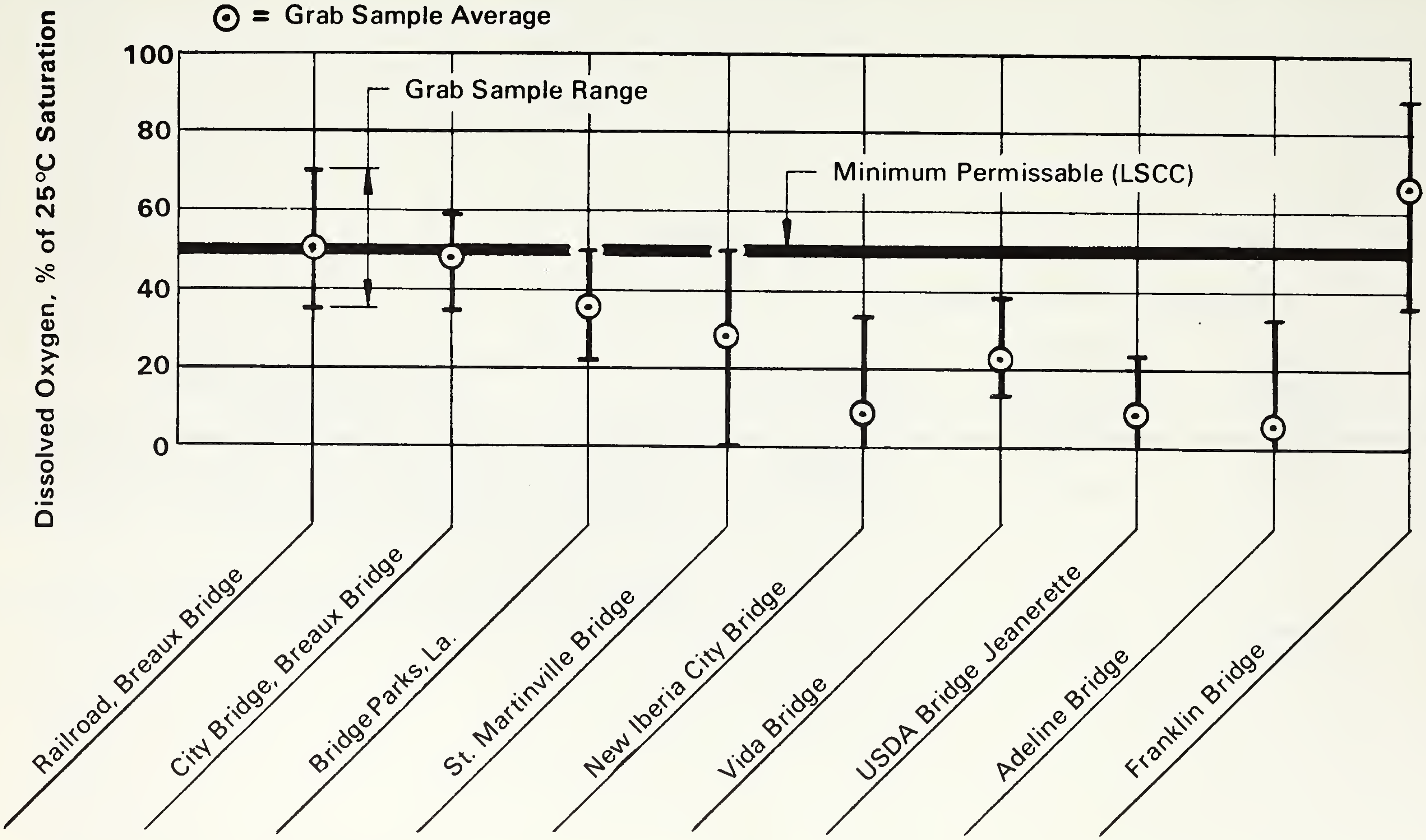


FIGURE 1 DISSOLVED OXYGEN VALUES, BAYOU TECHE, 1967 GRINDING SEASON

BIO-OXIDATION

When BOD is due to carbohydrates such as sucrose, the most efficient and economical means of reducing the BOD_5 values to the 20-30 mg/l range is through biological oxidation (bio-oxidation). Many process variation are used to accomplish bio-oxidation but all have in common the one characteristic depicted on **Figure 2**.

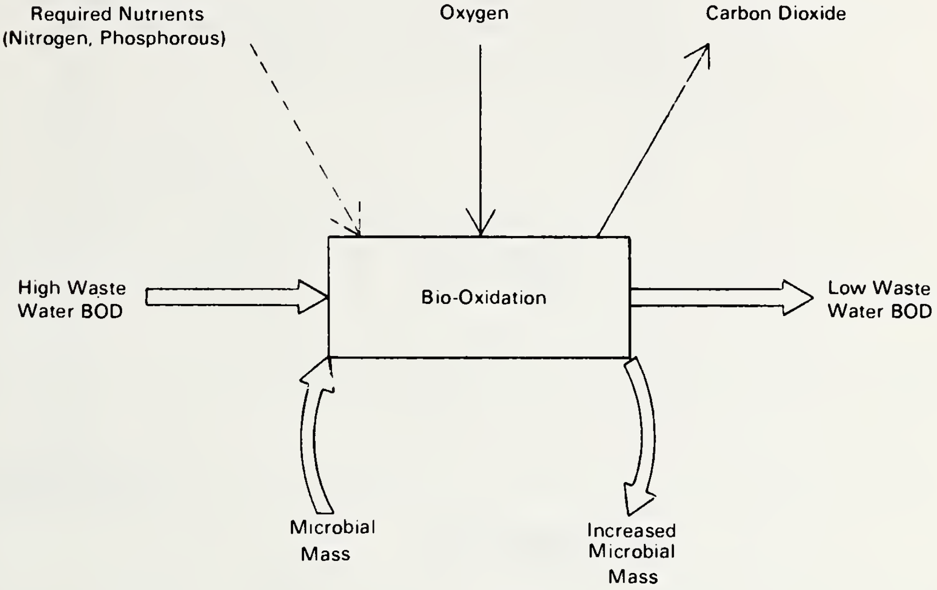
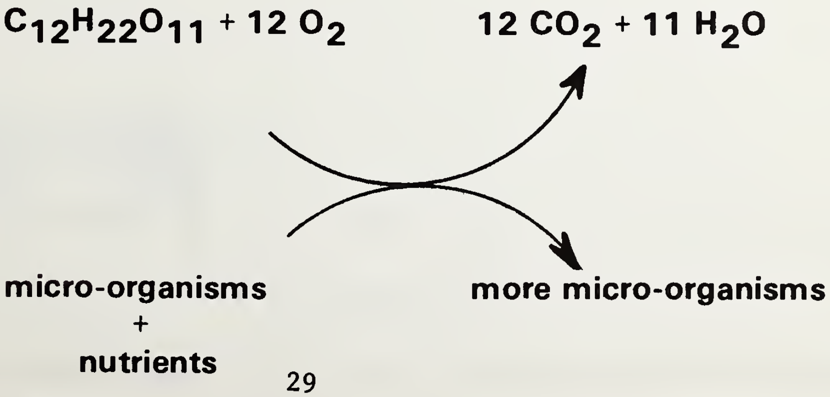


FIGURE 2 MASS CONVERSIONS IN BIO-OXIDATION

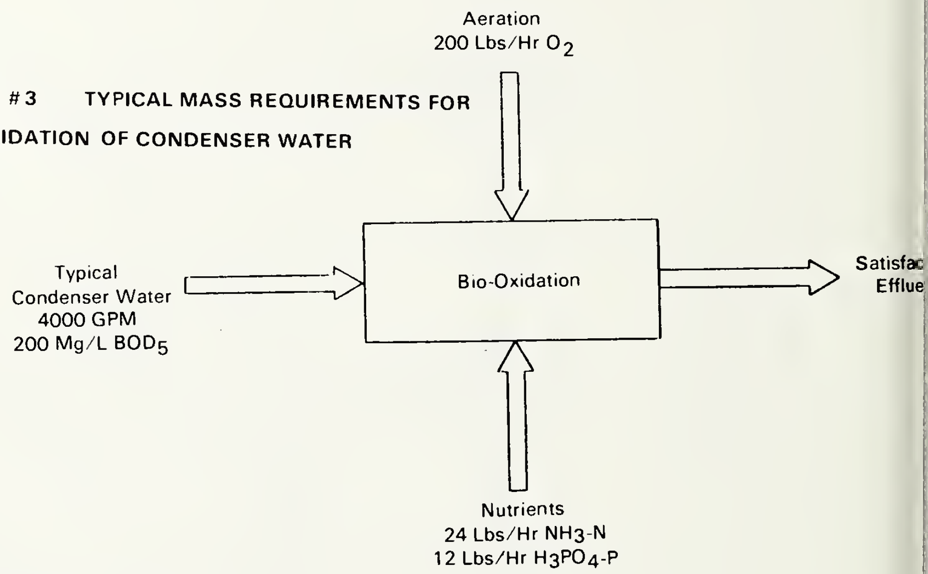
The waste water containing dissolved oxygen and other nutrients necessary for growth, is maintained in contact with an actively growing population of micro-organisms. The result, according to reaction (1), is conversion of the soluble sucrose mass ($C_{12}H_{22}O_{11}$) to carbon dioxide, water, and, more micro-organisms.



$$C_{12}H_{22}O_{11} + 12\ O_2 \qquad 12\ CO_2 + 11\ H_2O$$

A typical sugarcane mill might discharge 4000 gallons per minute (gpm) of condenser water containing 200 mg/l of BOD_5 but devoid of the essential nutrients nitrogen (N) and phosphorous (P). (10) The most economical form in which these nutrients can be supplied are as anhydrous ammonia (NH_3-N) and phosphoric acid (H_3PO_4-P). **Figure 3** depicts the oxygen, nitrogen, and phosphorous mass requirements for suitable bio-oxidation of a typical mill's condenser water according to reaction (1).

FIGURE # 3 TYPICAL MASS REQUIREMENTS FOR BIO-OXIDATION OF CONDENSER WATER



JET AERATION

A major equipment requirement in the bio-oxidation process is the aeration unit. Aeration serves at least two purposes in this process:

1. Supply and maintenance of the oxygen necessary for bio-oxidation to proceed.
2. Supply of sufficient turbulence and flow to maintain the micro-organisms in suspension and in contact with the bulk of the soluble sucrose.

A device which effectively accomplishes both these purposes and which, in addition, can be used to efficiently introduce and dilute the influent waste water, depicted on **Figure 4,** is the Jet Aerator.

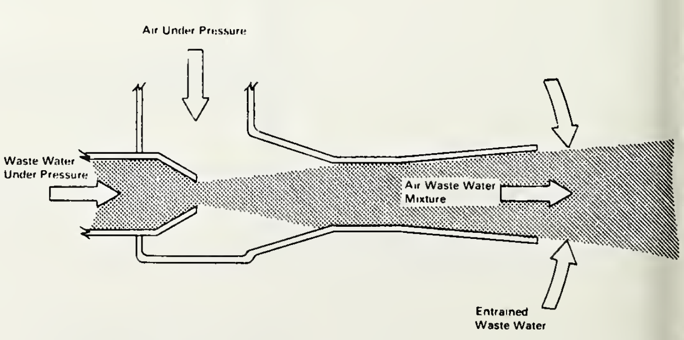


FIGURE # 4 OPERATION OF A JET AERATOR

This device, which mixes and transfers oxygen to a waste water by discharging a air-water jet into the bulk liquid, has been employed with mechanically compressed air (11, 12, 13) and aspirated air (14). The oxygen transfer performance of a jet aerator (maximum pounds of oxygen transferred per ideal horsepower-hour) is given on **Figure 5**.

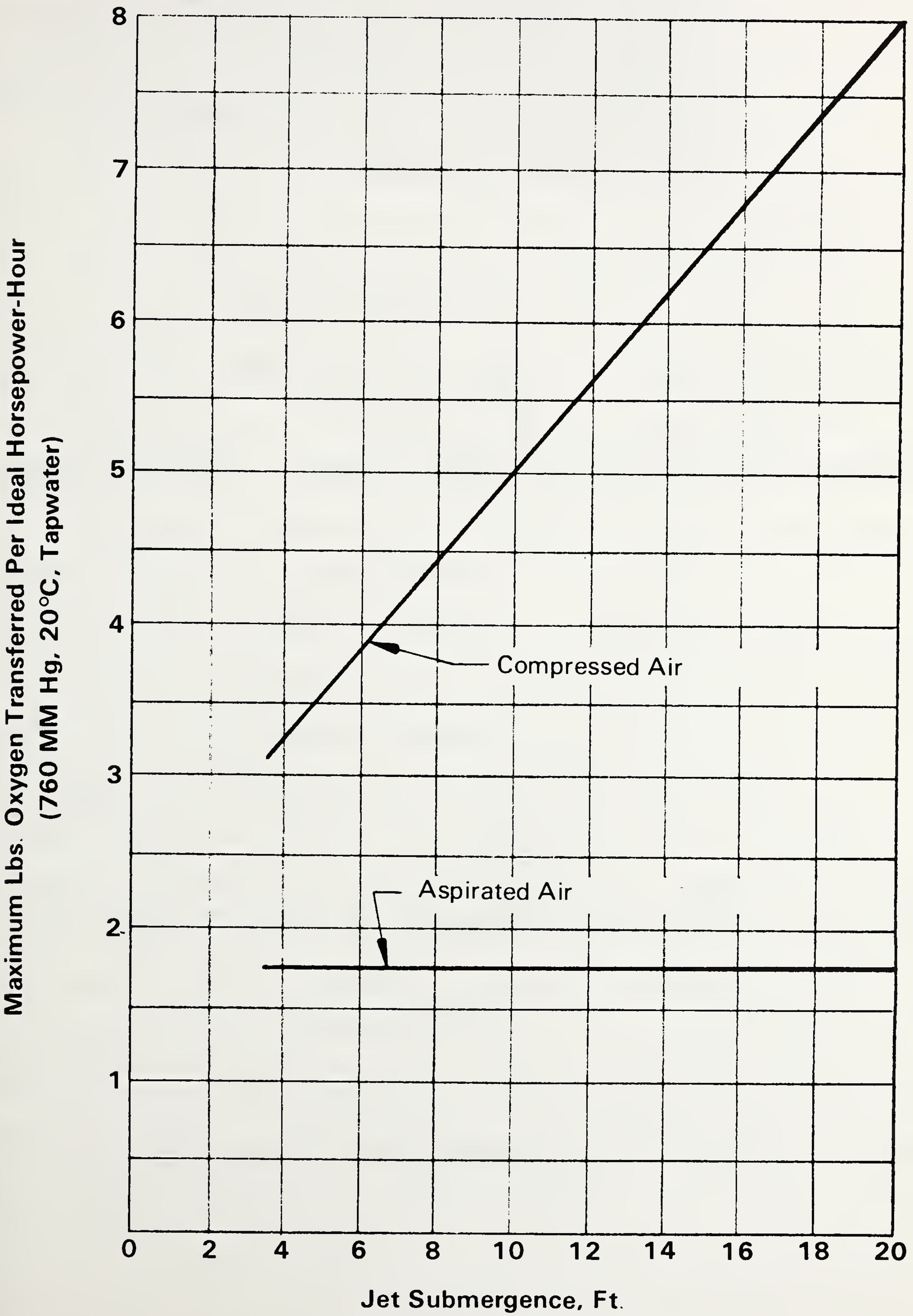
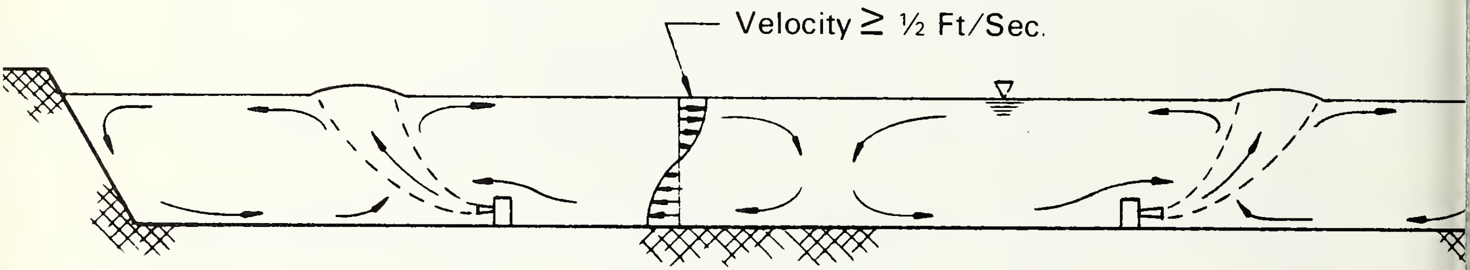
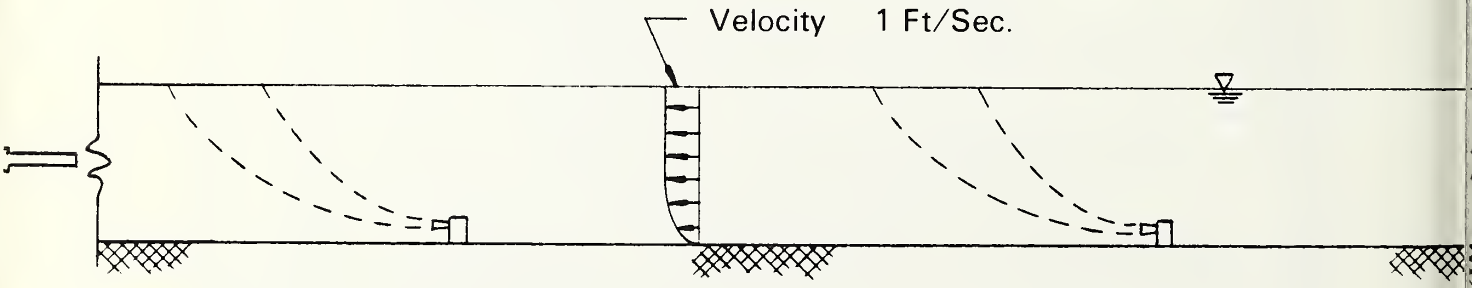


FIGURE 5 JET AERATOR OXYGEN TRANSFER PERFORMANCE

As the figure indicates, compressed air performance of the jet aerator is substantially higher than aspirated air performance with the former increasing with increase in jet submergence depth. As depths increase above ten feet the jet aerator performance exceeds that of other commercially available aeration equipment. (15, 16). **Figure 6** represents the type of mixing patterns established in two bio-oxidation processes which would have application for treatment of condenser waters—the aerated lagoon and the oxidation ditch. The velocities generated in the bulk liquid by the Jet Aerator force should be sufficient (17) to maintain the micro-organisms in suspension.



Aerated Lagoon



Oxidation Ditch

FIGURE 6 BULK MIXING PATTERNS WITH JET AERATION

APPLICATIONS OF JET AERATION

Figure 7 depicts a Jet Aeration module for use in an aerated lagoon suitable for treatment of condenser waters by the bio-oxidation process. The axial flow pump and air compressor are mounted on top of a platform located centrally in the lagoon. An air-water manifold circumscribing the platform at the submergence depth (two feet above the lagoon bottom) is supplied by the pump and compressor. The Jet Aerators are mounted uniformly about the periphery of the manifold. This module, exclusive of the supporting platform, costs in the neighborhood of $150 per installed brake-horse power, and, at a ten foot submergence, will supply oxygen at a cost of two mils per pound of oxygen transferred. An aerated lagoon utilizing the Jet Aeration module and producing an effluent meeting the LSCC standards is shown on Figure 8. Space requirements were calculated from the results of kinetic studies conducted on sugar cane waste waters. (18)

When sufficient land space is available the aerated lagoon is an inexpensive form of the bio-oxidation process. For those mills with limited available land space, the oxidation ditch form of the bio-oxidation process provides an economical alternative. Originally developed in the Netherlands (19) for small rural communities, the oxidation ditch has been adapted to a number of applications in the United States (20, 21) Jet Aerators, in producing a directed force, will maintain a velocity in the ditch sufficient to maintain a good mixture (Figure 6). Figure 9 depicts a manifolded Jet Aerator module for mixing and aerating an oxidation ditch system. A design employing such modules for treatment of a typical sugar cane mill's condenser water is shown on Figure 10. It will be noted that the area requirements of the oxidation ditch are approximately 5 per cent of those for the aerated lagoon.

The space requirement is less for the oxidation ditch due to the higher concentration of micro-organisms maintained in it. This is accomplished by passing the ditch effluent through a mechanically cleaned solids separation unit (sedimentation, or, floration) and recycling the collected solids back to the ditch. The clarified effluent from the solids separation unit is discharged directly to the receiving water.

JET AERATION VARIATIONS

Although the Jet Aeration modules exclusive of supporting platforms as described above can be generally employed for aeration of condenser water, the variations listed on Table II may be of interest to particular sugar cane mills.

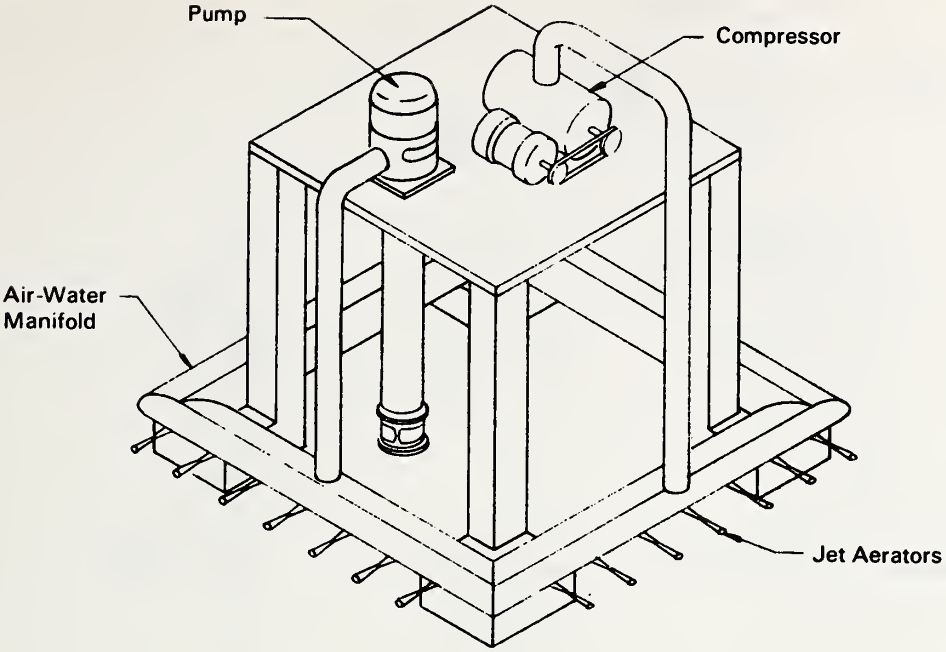


FIGURE #7 JET AERATION MODULE FOR AERATED LAGOON

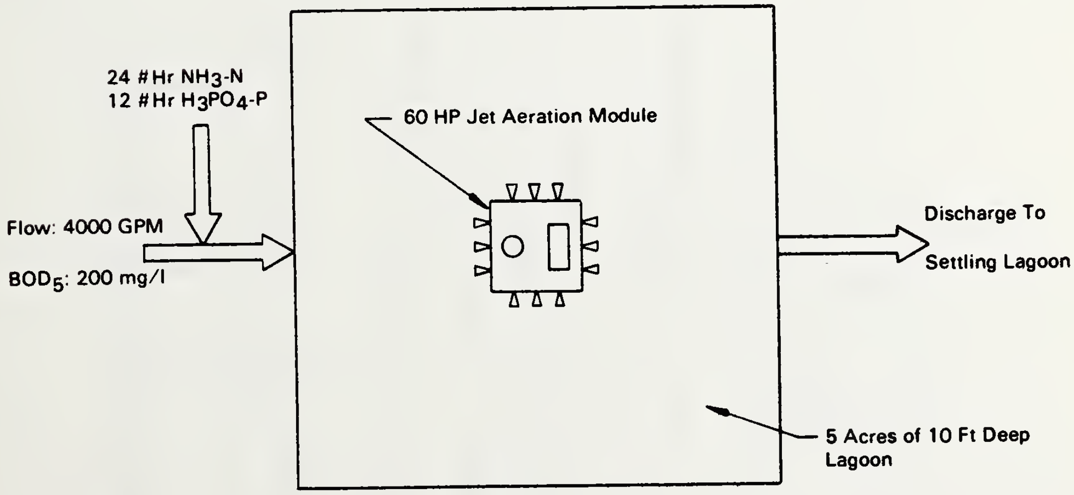

24 #Hr NH_3-N
12 #Hr H_3PO_4-P
Flow: 4000 GPM
BOD_5: 200 mg/l
60 HP Jet Aeration Module
Discharge To Settling Lagoon
5 Acres of 10 Ft Deep Lagoon

FIGURE #8 AERATED LAGOON APPLICATION OF JET AERATION

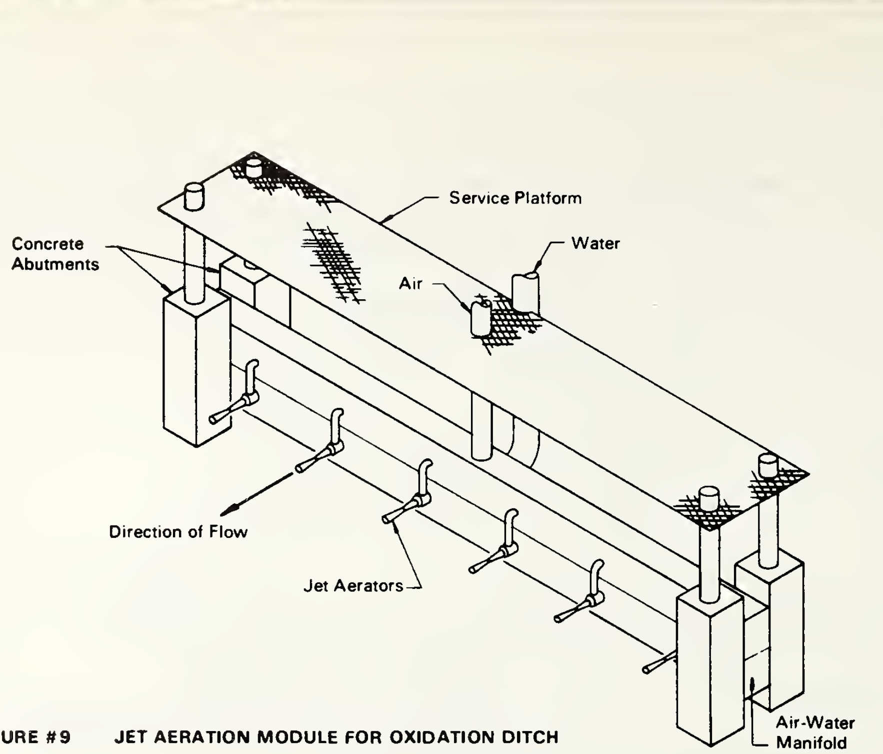


FIGURE #9 JET AERATION MODULE FOR OXIDATION DITCH

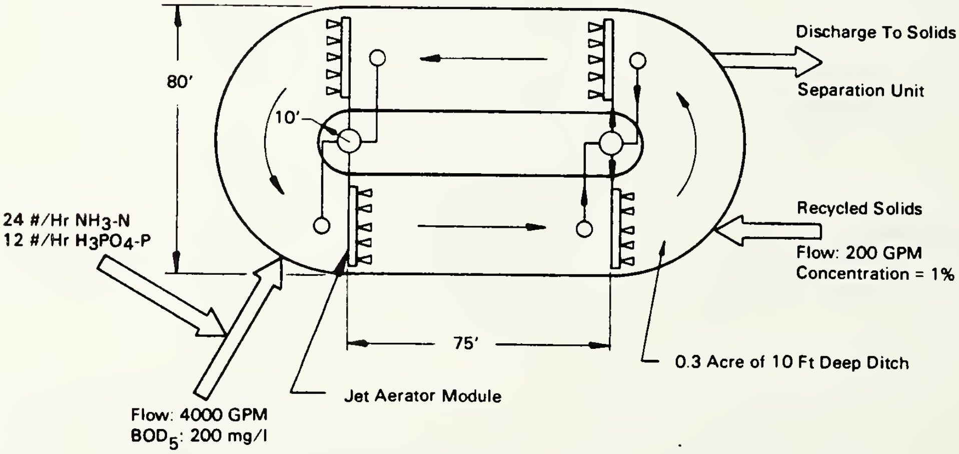


FIGURE #10 OXIDATION DITCH APPLICATION OF JET AERATION

TABLE II

1. Module Fabrication by the Mill

Pump, compressor and module piping purchased and installed by mill per specifications provided by Jet Aerator supplier.

2. Pump Only Module

Jet Aerator operated as an aspirating unit, eliminating the need for the air compressor. The power required by such a unit would be approximately three times that of the compressed air module.

3. Waste Steam for Air Compression

For waste treatment application in close proximity to the mill waste steam can be utilized through a steam-air ejector for compressing air, thereby eliminating the air compressor while maintaining compressed air oxygen transfer efficiencies.

SUMMARY

In meeting the requirements of the LSCC Water Quality Criteria (4) the aerated lagoon and oxidation ditch provide the two most economical forms of the bio-oxidation waste water treatment process for use by Louisiana's sugar cane industry. Table III summarizes the major characteristics of each form. Substantial space is required for an aeration lagoon, but, beyond the aeration module and nutrient handling facilities, there is no further equipment requirements. Land requirements for the oxidation ditch are significantly less but the equipment requirements are increased by the requirement for a solids separation unit. The characteristic cost for such a unit in place would be $50,000 (22). Assuming that an aeration lagoon would require an additional half acre for biological solids sedimentation, lagoon land purchase and construction costs would have to exceed $10,000 per acre to justify the oxidation ditch over the aerated lagoon. Oxygen and nutrient requirements are similar for each system.

A generalized estimate of the total first cost of either bio-oxidation process can not be made. Many mills already have adequately sized lagoons and thus, would not be faced with initial land purchase and lagoon construction costs. While some mills have otherwise useless land available for a waste treatment plant, others might have to acquire valuable land. Finally, it is difficult to estimate the savings which might result by using the mill's equipment and labor during the off season for waste treatment plant construction.

Under these circumstances the total first cost of either bio-oxidation process can best be estimated by each mill on an individual basis once the costs of the equipment required for aeration and mixing are specified. A Jet Aeration module can be applied to each process for meeting both oxygen transfer and mixing requirements. Characteristic initial and operating cost for the Jet Aeration modules as applied to the typical mill's effluent are recorded on Table IV. Initial costs are for the aeration modules including pumps and compressors but exclusive of supporting platforms. Operating costs are based on power costs of $0.01 per kw hr. Initial and operating costs would have to be adjusted for the Jet Aeration application variations listed on Table II. This can be done using the information on Figure 5 and on Table II together with the rule of thumb that the mechanical compressor cost represents one half of the aeration module's first cost.

Presenting the above information on the alternative of a low cost and efficient waste water treatment plant for Louisiana's sugar cane industry to meet the LSCC's regulatory requirements was the stated purpose of this paper. It is hoped that this information will provide each mill with the opportunity to investigate, independently, the particular application of Jet Aeration in the bio-oxidation process best suited to their circumstances.

TABLE III

Bio-Oxidation Process Requirements

Process	Space (Acres)	Special Facilities	Aeration Power (hp)	Nutrients (lbs/hr)	
				NH_3-N	H_3PO_4-P
Aerated Lagoon	5		60	24	12
Oxidation Ditch	0.3	Solids Separation Unit			

TABLE IV

Jet Aerator Module Costs

Equipment:	$12,000 - $16,000
Operation:	$ 10 per day $600 per season

REFERENCES

1. "Water; The Basic Chemical of the Chemical Process Industry", Marketing Research Department, Chemical Engineering, Research Report 2-2-6-7-2, p. 11.

2. Wheeler, J. E., and A. G. Keller, "Pollution Abatement in the Louisiana Sugar Industry", Louisiana State University, Engineering Experiment Station Bull 55, pp. 31 - 45, 1956.

3. Order, State of Louisiana Stream Control Commission, September 1, 1955.

4. "Water Quality Criteria and Plan for Implementation", State of Louisiana Stream Control Commission, 1968, pp. 28 - 30

5. Lafleur, Robert A., "Water Quality in Louisiana Streams Receiving Sugar Factory Wastes", December, 1968 Proceedings of the American Society of Sugar Cane Technologists, pp. 78 - 82.

6. Eckenfelder, W. W., Jr., D. J. O'Conner, Biological Waste Treatment, Pergamon Press, 1961.

7. Eckenfelder, W. W., Jr., B. J. McCabe, ed., Advances in Biological Waste Treatment, Sumposium Publications Division, Pergamon Press, 1963.

8. Rich, L. G., Unit Processes of Sanitary Engineering, John Wiley & Sons, 1963.

9. Gurnham, C. F., Principles of Industrial Waste Treatment, John Wiley & Sons, 1955.

10. Fossett, H., L. E. Prosser, "The Application of Free Jets to the Mixing of Fluids in Bulk", Proceedings of the Institution of Mechanical Engineers, London, 160, 224, 1949.

11. Harlow, I. F., T. J. Powers, "Pollution Control at a Large Chemical Works", IEC, 39, pp. 572 - 577, 1947.

12. Juberman, O., G. Krause, "Ejector Aeration in the Biological Treatment of Sewage", Chemie-Ingenier-Technik, 40, pp. 288 - 291, 1968 (German).

13. West, R. W., W. C. Paulson, "Jet Aeration in Activated Sludge Systems", JWPCF, 41, pp. 1726 - 1736, 1969.

14. Kountz, R. R., " Big Problem: Dairy Wastes - Striking Solution: Bio-Oxidation", Food Engineering, pp. 89 - 90, 1954.

15. Kalinske, A. A., "Power Consumption for Oxygenation and Mixing", in reference 7, pp. 157 - 168.

16. Tharp, C. E., "Modern Aeration Techniques", Water and Wastes Engineering, June, 1969, pp. 31 - 33.

17. Fair, G. M., J. C. Geyer, Water Supply and Waste-Water Disposal, John Wiley & Sons, p. 750, 1954.

18. Wheeler, J. E., "An Engineering Study of the Effluent Disposal Problems of the Louisiana Raw Sugar Industry", Ph D Dissertation, Louisiana State University, 1959.

19. Pasveer, A., "Developments in Activated Sludge Treatment in the Netherlands", in reference 7, pp. 291 - 297.

20. Papers in: Animal Waste Management, Cornell University Conference on Agricultural Waste Management, Syracuse, Bew York, January 13 - 15, 1969, pp. 160, 172, 185, 249.

21. Burchinal, J. C., C. R. Jenkins, "Ditches Provide Efficient Treatment", Environmental Science & Technology, 3, pp. 1170 - 1173, 1969.

22. Smith, R., "Cost of Conventional and Advanced Treatment of Wastewater", JWPCF, 40, 9, pp. 1565, September, 1968.

THE SUPPLE SYSTEM, A NEW ALTERNATIVE FOR CANE HANDLING ON THE MILL YARD

Glenn R. Timmons
Economist
American Sugar Cane League

In the next few years many of the sugar mills in Louisiana will have to make a decision concerning replacement of yard derricks. Until last year there were only two choices. Old derricks could be replaced with new derricks, or they could be replaced with bridge cranes. There is now a third choice called the Supple System.

What Is The Supple System

The Supple System is a new method of handling cane on the mill yard that may eliminate derricks at some mills. This system was first put into use by Mr. Ed Supple of Catherine Sugar Factory in Bayou Goula, Louisiana. He experimented with the new method in 1968, and put it into full practice in 1969. Since Mr. Supple was the first to adopt this new system of cane handling, I feel that it should bear his name.

The Supple System substitutes a heavy-duty, articulated tractor, commonly known as a payloader, for each derrick. As you know, payloaders normally have a bucket attached to the front of the machine, and are used to move soil, sand, shells, raw sugar, etc. Mr. Supple had a specially designed cane grab mounted on the payloader in place of the bucket. The lower tines of this grab are rigid, and the upper tines can be opened and closed with hydraulics.

With the Supple System, bulk cane is delivered to the mill in carts or trailers. It is dumped over a retaining wall onto the storage pad. The payloader-operator lowers the machine's lifting arms to place the grab on or near the ground. The upper tines of the grab are opened. The operator drives the machine toward the unloaded cane and pushes the grab tines into the pile of cane. When the grab is full, the operator closes the upper tines of the grab, compacting and holding the cane inside the grab.

The operator raises the grab into the air and backs away from the unloading station. He now has the option of either placing the cane in a storage pile or onto the feeder table.

The machine used at Catherine Factory was able to lift a grab full of cane nine feet nine inches above the ground. This was sufficient to stack the cane to an average height of eight feet all across the storage pad. Cane could also be placed on the feeder table with no difficulty. If additional height is required, longer lifting arms could be installed.

Since 1969 was the first time the Supple System was actually used to feed a mill, no cost data was available on the system. Also, there was no physical performance data available from any source concerning this machine's capacity in cane handling. For that reason, the American Sugar Cane League, at Mr. Supple's request, conducted a study of this new system during the 1969 season.

I would like to report the findings of that study at this time. The figures presented are the result of numerous observations, weighings, and timings throughout the 1969 season at Catherine and Cinclair Factories. It was orginally intended that this study would make comparisons between the Supple System, the derrick system, and the bridge crane system. However, because of the unusually short grinding season in 1969, not enough data was gathered on bridge cranes to accurately compare them with the Supple System. For that reason, the only comparison made will be between the conventional derrick system and the Supple System.

The first problem was to determine the work standard for the machines used in the Supple System. Each payloader with it's special cane grab was able to consistently lift one cart full of cane per grab full. During 1969, the average cart load of cane delivered to Catherine Factory contained 4.5 tons of cane. This meant that the payloader picked up an average of 4.5 tons of cane per grab full.

The cycle time was next determined. This is the time required by the payloader to pick up a load of cane and either place it in storage or on the feeder table and return for another load. This operation was timed a minimum of three hours per day for ten days. The average cycle time during that period was one minute twelve seconds. This held true for cane being placed either in storage or fed to the mill.

If each machine moved 4.5 tons of cane every one minute twelve seconds, then each machine was operating at an indicated capacity of 3.75 tons per minute or 225 tons per hour. This is the amount of cane each machine could handle if it were operated one hundred percent of the time, which is not realistic. By comparison, a derrick with a 12 ton grab and an 80 foot boom had an indicated capacity of 250 tons per hour. At Catherine Factory each machine ran 16 hours per day. It was not moving cane all this time. The other 8 hours of the day was available for preventative maintenance, refueling, and repairs. This is more than enough time to complete these duties.

It was found that both derrick and payloader was actually moving cane only 40 minutes out of each hour, or two-thirds of the time, therefore the indicated capacity of both derrick and payloader was adjusted by two-thirds. This gives a work standard of 150 tons perhour per payloader and 167 tons per hour per derrick. The work standard is that amount of cane that a machine can be expected to handle per hour over a long period of time. Each machine in the Supple System could reasonably be expected to handle 150 tons per hour and work an average of 16 hours per day.

One experience last year indicates that this work standard for the Supple System is reasonable. This experience is best explained in the following excerpt from a letter from Mr. E. Berkshire Terrill, Manager of Cinclair Factory to Ed Supple.

> ... As you know, in the early hours of the morning on December 4th, we broke a head shaft on our West Cane Table. This cane Table handles the delivery of all of our Bulk cane trailers. We realized that we were faced with a twenty-four to thirty-six hour repair job on this cane table and knew that we only had about forty-eight hours of grinding left for this crop year. A phone conversation to you around breakfast time advised us that you would be more than glad to loan us your Hough Front End Loader to help out. Our plan then was to unload all of the bulk cane with the Hydrunloader over the wall on our West yard and have the Hough Front End Loader take this cane over to our East derrick yard, where the derrick could put it on the East table. Your loader arrived around noon that day and at that time we decided instead of taking the cane from the West yard to the East yard, that we would transfer the cane from the West yard to an empty railroad car and have our railroad grab unload this cane on to the East Table. This worked out extremely well. During the night of the 4th we broke a shaft on the East derrick. This of course meant that we had nothing to feed either table with, and only had the railroad cars to operate the factory on. The next morning we took the grab off of the West derrick and put a bar on the cables so that we could unload sling cane on that yard. We went the full day unloading sling cane on to the West yard and unloading bulk cane over the wall with the Hydrunloader on to the West yard. For your information, the Supple System completely took care of feeding the mill and we were at that time grinding at a 3,000 plus ton rate...

This illustrates the flexibility of the Supple System. While operating one machine, under adverse conditions, the Supple System moved cane at an average of at least 125 tons per hour.

STORAGE REQUIREMENTS

When the Supple System was first introduced, storage requirements were unknown. Some felt that any mill adopting this new method would have to triple existing storage space. The League study did not bear this out. However, an increase in storage area would be required at some mills. This did not happen at Catherine, and I can not visualize any mill having to triple existing storage areas.

A derrick will stack cane much higher at a given point and denser than the Supple System, but it does a less efficient job of using available concrete space. A derrick does not use a large portion of the concrete area under the boom for several reasons. Cane is stacked in a doughnut-shaped pile because the center of the storage pad must be left clear in order for the derrick housing to pivot. Cane cannot be piled too high either in front of the feeder table or near the unloading station. In addtion, a lane is generally kept open in case maintenance vehicles are needed at the derrick.

By contrast, the Supple System makes better use of existing storage area. By actual measurement, the Supple System at Catherine Factory stacked cane to an average height of eight feet across the storage pad. The amount of cane stored on the yard at Catherine Factory during one day was 1,846 tons. This amount of cane occupied 32,870 square feet of storage space. Since the cane was stacked at an average height of eight feet, the Supple System piled cane at a rate of 14 pounds per cubic foot.

The Spencer Meade, Cane Sugar Handbook, Ninth Edition states that the average bulk density of cane in a pile can vary from 25 pounds per cubic foot to 12 pounds per cubic foot. The Supple System falls within this range.

To illustrate the storage requirements of the Supple System as opposed to the conventional derrick system, a hypothetical mill situation is assumed. The yard layout is shown in figure 1. In our example, land is not a limiting factor.

The mill has two conventional derricks, one a 60' boom and the other an 80' boom. The big derrick could stack 1500 tons of cane for night grinding, but normally stacks only 1250 tons. The smaller derrick could stack 800 tons, but it normally stacks only 500 tons of cane.

In addition to the derricks at our mill, we also direct feed during delivery time. Direct feeding normally accounts for 3/4 of our hourly grinding rate during delivery time. The rest of the grinding needs are supplied by the derricks

In its present condition our mill has 20,106 square feet of concrete under the large derrick and 11, 310 square feet under the small derrick. All of this concrete is not available for cane storage for reasons mentioned previously.

Both derricks at our hypothetical mill are old and in need of replacement. For that reason, the decision has been made to study both the Supple System and the conventional derrick system as both would apply to our mill.

We know from data collected at Catherine Factory in 1969 that the Supple System will stack 14 pounds of cane per cubic foot. Since we want to be able to stack up to 2,300 tons of cane we can easily compute the required storage area.

Using 14 pounds per cubic foot and an average stack height of eight feet, we compute that our mill will need 41, 071 square feet of actual storage space to stack 2,300 tons of cane. The proposed yard layout with the Supple System is shown in Figure 2. In addition to storage, an operating lane 25 feet wide is provided on each pad for each machine. This operating lane runs the complete width of the storage pad directly in front of the feeder table. In addition, one pad has another 25 foot wide lane to accommodate direct feeding of the mill. The only equipment change required would be swapping payloaders for derricks.

The total increase in storage pad (includes operating lanes) requires an expansion of 63% in existing storage pads.

In this example, changing from a derrick system to the Supple System requires an additional 19,744 square feet in concrete. 8,584 square feet of the increase is realized by squaring off the corners of the existing round pads. Some mills may have this additional concrete available but unused because of the circular storage required by a derrick. It is important that all the concrete the machine will operate on be reinforced-concrete, poured on a well drained base. Following is the type of slab-construction recommended by LSU engineers for the Supple System.

One foot of river sand used as a base. Concrete used is a mixture of cement, sand and gravel in a ratio of 1:2:3 respectively. No more than 6 gallons of water per sack of cement is used. Reinforcement is achieved with 3/8" rods. Slab is poured in sections not more than 20 square feet. Curing is the wet process for 25 days at 70° Fahrenheit, or more.

HANDLING CAPACITY

Assume that our hypothetical mill grinds 3,000 tons per day. If cane is delivered 10 hours per day, then it comes into the mill yard at a rate of 300 tons per hour. During delivery time, 94 tons per hour is dumped directly onto the feeder table. The payloaders supply the additional 31 tons per hour to feed the mill. In addition they add 175 tons per hour to storage. Therefore, each payloader will hav to handle 103 tons per hour which is 69% of the work standard established for each machine.

Once deliveries have been completed, the work load on each machine becomes one-half the hourly grinding rate of the mill. In our example, this is 62.5 tons per hour. This represents only forty-one percent of the work standard established for each payloader.

Since each machine will work at 69% of its established work standard during delivery hours and only 41% the rest of the time, a back up machine will not be purchased. It is felt in our example, that since one machine can actually feed the mill and still store 25 tons per hour during delivery time, the excess capacity is in effect a back up.

Since our mill dumps direct on the feeder table during the day, the mill could actually grind more cane per day if cane were available and the payloaders could be used to do nothing but build up storage. Assuming that each machine achieved its work standard of 150 tons per hour, then 3,000 tons of cane could be stockpiled in a normal ten hour delivery period. If this cane were ground over a fourteen hour period, the capacity of our mill could expand up to 5,000 without exceeding the wor standard of the Supple System. However, this would require further expansion of storage area and at least one back up machine.

The hypothetical 3,000 ton mill is used to illustrate several points concernin the physical characteristics of the Supple System. Storage space is not as limitin as was once thought. The machines used in the Supple System have greater capacity than initially expected. With proper yard layout and the average operator, the worl standard of 150 tons per hour during a 16 hour day can be achieved.

In figure 2 we have allowed a lane 25 feet wide on each storage pad for operation of the machine. Each machine has articulated steering, is nine feet wide and can turn around in an area 22 feet by 22 feet. Therefore, this operating lane should be adequate. It is important that the operating lane occupy as little of the storage space as possible. For that reason the dumping station should be as close to the feeder table as possible.

COST OF THE SUPPLE SYSTEM VERSUS CONVENTIONAL DERRICK SYSTEM

We have seen that there is no physical limitation that would rule out the introduction of the Supple System at our hypothetical 3,000 ton mill. Next, and most important, we must look at the cost of the Supple System versus another derrick system.

The installed cost of one new 6-ton capacity, guyed, steel, AC-DC individual motor drive derrick with a 60 foot boom including paved unloading site and derrick stand (see table 1) is $125,000. A similar derrick with an 80' boom and 12 ton capacity cost $137,000, (table 2). These figures were arrived at through discussion with mill managers who have both purchased and priced similar derricks recently. This is the complete cost to the mill of an installed derrick. These derricks would have a 20 year life. Beyond this period it would be more economical to replace the original derrick because of increasing maintenance costs.

The combined annual depreciation of both derricks is $13,125. Since money used to purchase these derricks cannot be invested in other profitable areas of mill operation, an interest rate must be charged to this investment. This is true whether money is borrowed or not. The interest rate assigned in this case is 7%. Assuming straight line depreciation on all equipment, annual interest charges can be determined by applying the interest charge to one-half of the initial investment which is the average investment. Interest cost for both derricks is $9,187.50 annually.

Ad-valorem taxes must be paid on factory owned equipment. The exact tax amount is based on assessed market value and varies widely between areas. Propert taxes on factory owned equipment is estimated at 1% of the initial investment. The annual tax cost of both derricks is $2,625.

By the same token, insurance rates on factory equipment vary from mill to mi however, an estimated insurance cost of .5% of initial investment has been assumed. The annual insurance cost of both derricks is $1,312.50.

For planning purposes, it is assumed that an average grinding season will be 70 days per year. The annual cost of each system will be spread over the entire length of this assumed average grinding period. For comparison purposes, hourly cost of operation will be determined. This is done by dividing total annual cost by the number of hours in the 70 day grinding period. This is 1,680 hours.

This procedure is followed in Table 1 and 2. The hourly fixed cost, which is the cost of simply owning but not operating both derricks is $15.62. Electric power for both derricks cost $1.50 per hour. Repairs and maintenance cost $6.562 per hour for both derricks. Therefore, it costs $8.06 per hour just to operate both derricks. The total cost of both owning and operating both derricks is $23.68 per hour.

You will notice that labor costs have been excluded from this analysis becau the Supple System, under most conditions, will not result in a reduction in labor However, some mills may find that payloader operators are not as hard to train as derrick operators and therefore not paid as much. Since each system requires the same amount of labor, and labor costs vary from mill to mill these costs have bee purposely excluded. Anyone interested can easily plug in their own hourly labor costs.

The same procedure was followed in analysing the cost of the Supple System. One payloader of the type and size used at Catherine Factory cost $46,000 (table

Naturally, its life will not be as great as that of a derrick. The useful life of a payloader is estimated to be 12 years, no trade-in value is assigned the payloader.

Depreciation at that rate will cost $3,833.33 annually. Interest will be $1,610 annually, and taxes and insurance combined will cost $690 each year. This breakdown is shown in table 3. The total cost of owning each payloader will be $6,133.33 annually or $3.651 per hour.

Each payloader requires 54¢ for fuel each hour. Oil and filters cost 22¢ per hour, and tires another 95¢ per hour. $2 per hour is allocated for repairs and maintenance for each machine. The total cost to operate each machine is $3.71 per hour.

The combined cost of owning and operating each payloader is $7.36 per hour. Since our hypothetical mill would use 2 payloaders, the hourly machine cost of The Supple System would be $14.72. However, it must be remembered that when conversion was made to the Supple System at our hypothetical mill, storage space had to be expanded about 63%. Assuming that none of this concrete was present before, we must estimate the cost of this extra storage space.

It has already been determined that an additional 19,744 square feet are needed when adopting the Supple System. The assumption is made that the existing storage pad is well constructed and will support the machine used in the Supple System.

Based on these assumptions it would cost $13,300.40 initially to expand our storage to the required amount (table 4). Based on 1,680 hours annual use this would cost 67¢ per hour for added storage. In fact some mills would not incur this entire cost because they may have some additional concrete space already available or could use their own labor to pour concrete.

The costs per hour derived in Tables 1, 2, 3, & 4 are presented in the following summary form.

Amount	Item	$/Hour
1	derrick with 60 foot boom	$11.31
1	derrick with 80 foot boom	12.37
1	19,656 sq.ft. expansion of existing storage pad	.67
1	payloader like one used at Catherine in 1969	7.36

Using the figures derived in the various tables and summarized above it would cost $23.68 per hour to replace existing derricks with two new ones. The cost of switching to and operating the Supple System with two machines would be $14.72 per hour for payloaders plus $.67 per hour for expansion of two existing storage pads. This is a total of $15.39 per hour. Therefore, using two payloaders in the Supple System at our hypothetical mill would cost $8.29 per hour less than using two new derricks.

If we had elected to purchase three machines, using one as a back up, the total cost per hour of the Supple System would become $22.75 per hour (this includes the cost of storage pad expansion). The three-machine Supple System at the example mill would still cost $.93 per hour less than the conventional derrick system. This slightly over states the cost of the Supple System, using a third machine as a backup. I have assigned full cost of owning and operating to the backup machine. In reality the backup payloader would be cheaper than the operating machine because of longer life expentancy and lower fuel, tire, and repair costs.

Some people have voiced concern over the amount of cane crushed on the mill yard by the Supple System. Using our hypothetical mill with two payloaders we would have to crush over 13 net tons of cane per day to eliminate the cost savings over the conventional derrick.

SUMMARY

In summary I would like to point out the more important points of this paper. First of all this paper does not conclude that every mill in Louisiana should immediately replace existing derricks with the Supple System. However, it is felt that the Supple System has proven through two grinding seasons that it should be seriously considered when existing derrick systems have to be replaced.

This paper was limited to explaining the possibility of adapting the Supple System to mill yard use through the use of a hypothetical mill . The conditions assumed to exist at this hypothetical mill are not the only ones under which the Supple System will operate. Every mill has different conditions, and mill managers should use their imagination in trying different variations of the Supple System at their own particular mills.

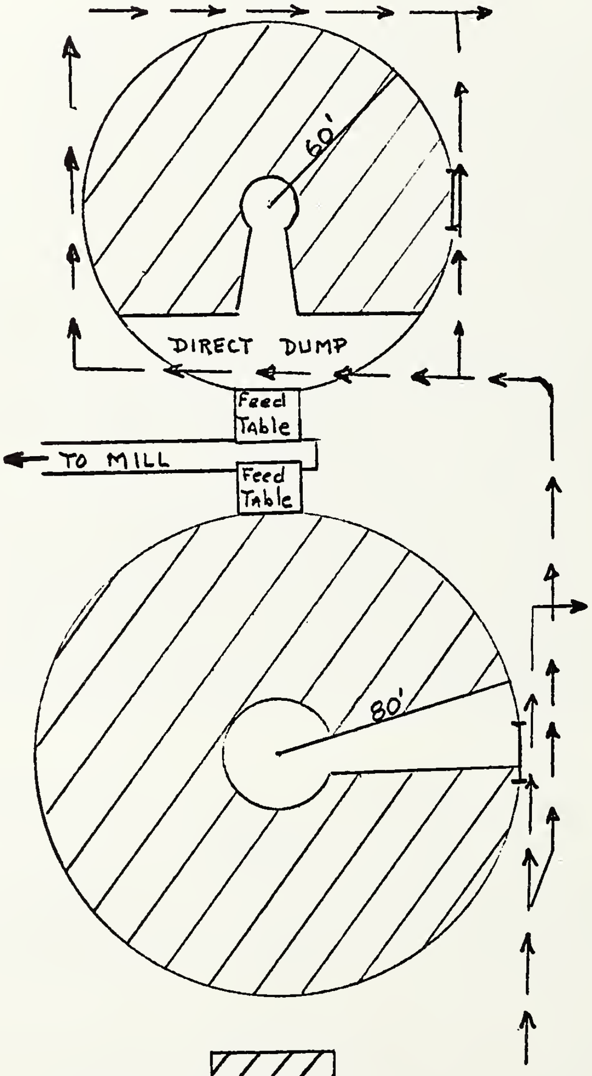
The Supple System has some definite advantages that should appeal to most mill people. Probably the most significant non-economic advantage is the ease with which operators can be trained. At Catherine Factory it was found that four hours was the average time required for an operator to become proficient.

There are other possible uses for the payloaders outside of grinding season. With the standard bucket attachment they could be leased to construction companies, or used to load shells, sand, or soil. Some mention has been made concerning the possible use of the machines in heavy duty cultivation and land leveling. This of course gives the Supple System a very definite advantage over the derrick system. No one has yet found another use for a derrick.

The Supple System is much more versatile on the mill yard than a derrick system. It makes it possible to pick up dropped cane on the mill yard. If one feeder table breaks down, cane can still be fed from two storage areas onto the remaining feeder table.

In conclusion, the Supple System has the ability to make both an economic contribution and reduce labor worries at some Louisiana mills. It deserves consideration whenever replacement of existing cane handling systems becomes necessary.

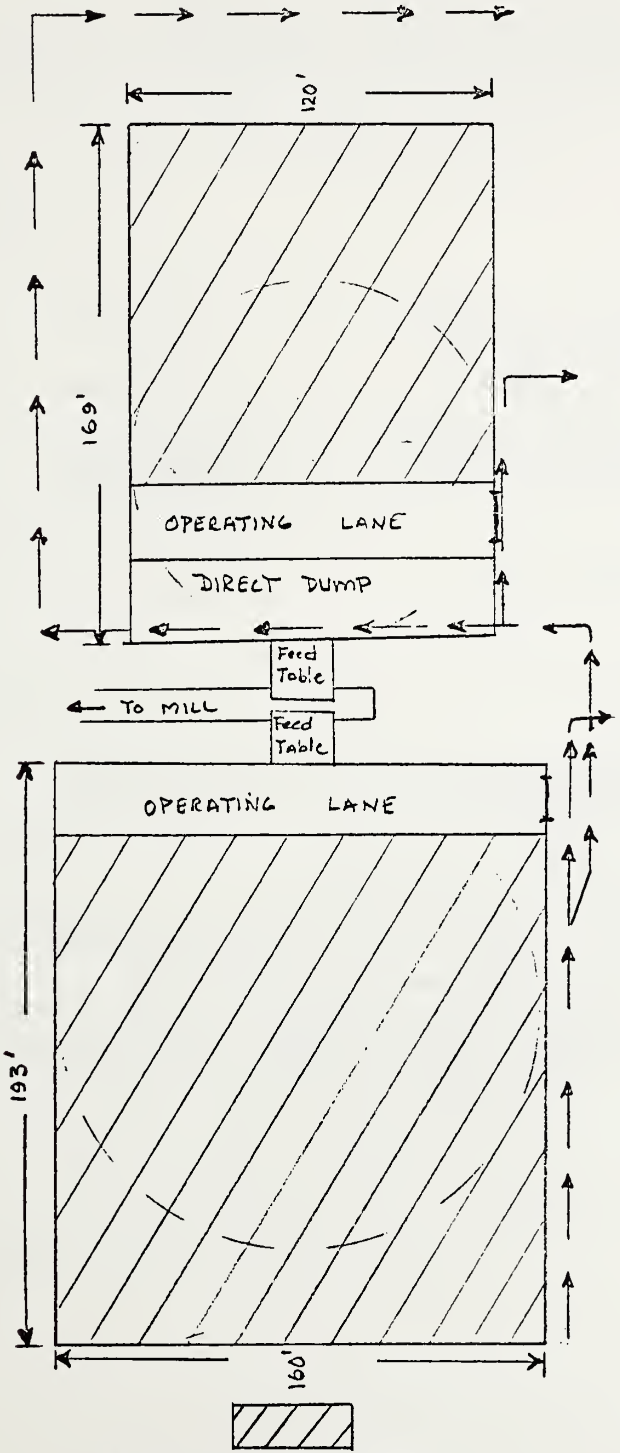
Figure 1: Hypothetical Mill Yard Using Conventional Derrick System; 3,000 Ton Per Day Capacity.



▨ Available Storage Area

Total Concrete Surface is 31,416 ft^2

Figure 2: Hypothetical Mill Yard Using Supple System; 3,000 Ton Per Day Capacity.



Available Storage Area

Total Concrete Surface is 51,160 ft^2

Table 1: Installed cost of a 6-ton capacity, guyed, steel, all electric AC-DC individual drive motors, derrick with a 60 foot horizontal boom. Cost includes paved unloading site and derrick stand.

INITIAL INVESTMENT		---Dollars---
Derrick		125,000
Annual Fixed Costs		
Depreciation (20 year life)	6,250.00	
Interest (7% of ½ initial investment)	4,375.00	
Taxes and insurance (1.5% of initial investment)	1,875.00	
Annual Fixed Cost	12,500.00	
Total Fixed Hourly Costs[a]		7.440
Variable Costs Per Hour		
Electric Power[b]	.750	
Repairs and Maintenance[c]	3.125	
Total Variable Costs	3.875	3.875
TOTAL COST PER HOUR (Minus Labor)		11.315

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[a] Based on 1,680 hours annual use (70 days at 24 hours per day)

[b] Estimated at .015 per hour per motor horsepower

[c] Estimated at 0.25% of initial investment cost per 100 hours use. Includes cost for all lubrication, hoist and cable repair and replacement all derrick repairs and maintenance, and all minor and major engine repairs and maintenance.

Table 2

REVOLVING DERRICK: Installed Cost of a 12-ton capacity, guyed, steel, electric powered unit with a 80 foot horizontal boom AC-DC individual motor drive. Cost includes paved unloading site and derrick stand.

INITIAL INVESTMENT COST		----Dollars----
Derrick		137,500
Annual Fixed Costs		
Depreciation (20 year life)	6,875.00	
Interest on investment (7% of ½ initial investment)	4,812.50	
Taxes and Insurance (1.5% of initial investment)	2,062.50	
Annual Fixed Costs	13,750.00	
Total Fixed Hourly Cost[a]		8.185
Variable Costs Per Hour		
Electric Power[b]	750	
Repairs and Maintenance[c]	3.437	
Variable costs per hour	4.175	4.187
TOTAL COST PER HOUR (minus labor costs)		12.372

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[a] Based on 1,680 hours annual use (70 days at 24 hours per day)

[b] Estimated at .015 per hour per motor horsepower

[c] Estimated at 0.25% of initial investment cost per 100 hours use, includes cost for all lubrication, hoist and cable repair and replacement, all derrick repairs and maintenance, and all minor and major engine repairs and maintenance.

Table 3.

SUPPLE SYSTEM: Front-end Payloader, International Harvester, H-80 DT-429 Diesel Engine, 6 cylinder, 429 cu. in. with front end mounted cane grab.

		----Dollars-----
INITIAL INVESTMENT		
Payloader		46,000.00
Depreciation Payloader (12 years)	3,833.33	
Interest (7% ½ investment)	1,610.00	
Taxes (.5% investment)	230.00	
Insurance (1% investment)	460.00	
Annual Fixed Costs		6,133.33
Total Fixed Hourly Costs[a] (1,680 hours)		3.651
VARIABLE COST PER HOUR		
Fuel 3 G.P.H. @ 18¢/Gal.	.540	
Oil & Filters	.221	
Repairs and Maintenance	2.000	
Tires	.947	
Variable Costs Per Hour		3.708
TOTAL COSTS PER HOUR (Minus labor costs)		7.359

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[a] Based on 1,680 hours annual use (70 days @ 24 hours per day)

Table 4. Cost of pouring, 19,744 ft.^{2} of additional concrete storage pad as required by adoption of the Supple System at our hypothetical mill. Concrete slab is poured 6" thick on one foot of river sand, reinforced with 3/8" reinforcing rods every 18".

INITIAL INVESTMENT COST		---Dollars---
Concrete (366 yd^3 at \$17.00/yd^3)		6,222.00
River Sand 732 yd^3 at \$2.00/yd^3)		1,464.00
3/8" reinforcing rods (25,600 linear feet at \$2.65/linear foot)		678.40
Labor Costs[b]		4,936.00
		13,300.40
Annual Fixed Costs		
Depreciation (20 year life)	665.02	
Interest on investment (7% of ½ initial investment)	465.51	
	1130.53	
Total Hourly Fixed Cost[a]		\$ .673

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[a] Based on 1,680 hours annual use (70 days at 24 hours per day)

[b] Estimated by the Portland Cement Association at \$.25/ft^2

REMOVAL OF STARCH FROM SWEET SORGHUM JUICES[1]

By

B. A. Smith, R. C. Smith, R. V. Romo, R. A. de la Cruz, and
F. P. Griffiths

Food Crops Utilization Research Laboratory, Weslaco, Texas[2]

INTRODUCTION

The sweet sorghums have been recognized in the United States as a potential source of commercial sugar production for over a hundred years, but for a variety of reasons this potential has never been realized to the extent that a stable sorghum sugar industry has been established. A number of small sorghum sugar and syrup factories were built during the 1870's and 1880's across the central portion of the United States from New Jersey to Kansas, but the problems which they encountered usually resulted in abandonment of sugar production efforts within a few years. Harvey W. Wiley was closely associated with these various enterprises and acted as adviser in attempts to resolve the difficulties which developed, and in his reports and summaries for the U.S. Commissioner of Agriculture provided detailed data regarding field and factory operations (15, 16, 17, 18, 19, 20, 21, 22). He identified most of the problems faced by the various factories and attributed their failures to one or more of the following: (1) lack of pedigreed seed to provide plants with a reasonably constant percentage of crystallizable sugar; (2) rapid loss of sucrose in the stalk between harvest and juice extraction; (3) crudeness and inefficiency of processing machinery; (4) lack of a chemical technology designed for the sweet sorghums; and (5) depressed world market price for sugar.

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[1] Presented at the February 5, 1970, meeting of the American Society of Sugar Cane Technologists in Baton Rouge, Louisiana, and published in the Proceedings of this Society.

[2] One of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

Some but not all of the problems encountered in these early sugar production efforts have been resolved as more effective sugar technologies have evolved in the sugar cane and sugar beet industries, and as more precise methods of detecting and measuring juice and syrup constituents have been developed. Wiley (15) had identified starch in the sorghum stalks and in the extracted juices, but he did not attribute any of the difficulties encountered in juice clarification and recovery of crystalline sugar to this juice constituent, although the high temperatures employed in juice clarification were certain to have gelatinized a substantial portion of the starch granules present. He noted that a "gummy matter" was responsible for reducing the quantity of sugar which could be separated from the molasses, and suggested the addition of ethyl alcohol to the 50° Brix syrups to precipitate this material. In 1923 Bryan and Sherwood (2) correctly identified starch as a juice constituent which would produce jelling in syrups when the starch granules were gelatinized during hot clarification and concentration processing, and later Sherwood proposed the destruction of the starch by treatment with malt diastase (8). Research reported by Willaman and Davison (23) and by Walton, Ventre and Byall (14) verified these findings. In 1940 Ventre (11) was successful in crystallizing sugar from sorghum syrups following removal of starch in a three-step procedure which involved centrifugation of the raw juice, followed by hot defecation at a pH of 8.3 to 8.5 and destruction of the residual starch with the enzyme pancreatin. He later identified and devised means of removing aconitic acid, another juice constituent which interfered with the crystallization of sugar from sorghum massecuites (12).

In 1951 R. H. Cotton, _et al_., (5) reported success in crystallizing sugar from sorghum juices which had been extracted by diffusion and clarified by carbonation, both of which procedures more closely conformed to conventional sugar beet than to sugar cane operations. In these investigations the small quantity of starch which escaped the carbonation clarification step was destroyed with pancreatin, and aconitic acid was eliminated by precipitation of its calcium salt according to the methods proposed by Ventre. It seem probable that the sugar cane or the sugar beet industries would have explored the results of these research findings in order to extend their annual processing seasons except for the lack of consistent sweet sorghum field performance records and established crop management procedures. Doubtless the expense of centrifuging large volumes of raw juice and the cost of the enzyme pancreation, both considered necessary for adequate starch elimination, acted as deterrents for the sugar cane industry.

The development and release of a new high-sucrose type, disease resistent sweet sorghum variety, Rio, in 1965 (4) renewed interest in the sweet sorghums as a replacement for several existing crops in the Lower Rio Grande Valley of Texas. A cooperative research program was undertaken to explore the sugar production potential of the sorghums, taking advantage of the newer field materials and the more advanced technologies and processing equipment now available. In this cooperative research effort, the Sugarcane and Sweet Sorghums Investigations of the USDA's Cropps Research Division would develop and supply seed from new sweet sorghum varieties and breeding lines, the Texas A & M University's Lower Rio Grande Valley Research and Extension Center at Weslaco, Texas, would plant and evaluate promising variety and nursery materials and conduct necessary field studies, while the Food Crops Utilization Research Laboratory of the USDA's Southern Utilization Research and Development Division at Weslaco would provide analytical assistance for the evaluation of various field materials and would also conduct research on the processing of the crop for sugar recovery. Progress with the first two phases of this program will be reported by others, while from the third or processing studies, only that protion concerned with procedures for eliminating starch from the extracted juices will be dealt with here.

MATERIALS

Raw juices used in these experiments were extracted by a single pass of hand stripped and topped stalks through a 3-roll Squier cane sampling mill which was hydraulically loaded to provide a force of approximately 30 tons on the upper roll. Juices extracted from mature stalks usually amounted to 50-60% of the stalk weight. A number of varieties of sweet sorghums, planted in various areas and at different times of the year, and harvested during their period of maximum sugar content, provided the juices used in these tests. Some tests were made with freshly extracted juices, and others with juices which had been stored in closed containers following extraction, promptly frozen with dry ice, and thawed when needed. No differences could be detected in the chemical composition of fresh and frozen materials.

ANALYTICAL METHODS

Most of the analyses of raw and clarified juices and the product syrups were made according to methods established by the cane sugar industry, including dry solids by low-temperature vacuum-oven drying on sand, carbonate ash after incineration at 550°C, reducing substances by the Lane-Eynon method, true purity based on chemical determination of sucrose by Lane-Eynon measurement of reducing substances before and after enzymatic inversion of sucrose, protein as Kjeldahl nitrogen x 6.25, Pol by polarization of a 26 gram sample, and spindle Brix. Two methods of measuring starch were employed, one based on measuring starch-iodine color as suggested by Balch (1), and the other based on phenol-sulfuric acid-starch color as reported by Dubois, et al. (6). Reference to the method of measurement will be noted where starch values are reported. Free acidity values are based on titration of a weighed juice sample with standard alkali to a pH of 8.3 and calculated as free aconitic acid. Aconitic acid determinations were made by the colorimetric method of Poe (7). All analytical data except the measurement of a solid matter have been calculated to a dry solids basis to permit a uniform accounting of the various juice constituents during processing, and as well a more accurate measurement of the changes which occurred as a result of processing procedures. All sample aliquots for analysis were weighed from well mixed bulk materials, so that raw and clarified juice analyses were made on mixed juice rather than a settled juice basis in order to account for the large quantities of suspended matter extracted with the raw juices and the small quantities remaining on occasion in the clarified materials. Spindle Brix measurements of juice solid contents do not include this suspended material, so that Brix values are not reported or used in evaluation of the experimental data. The use of dry solids purities rather than apparent purities in reporting the results of these experiments, where the Pol reading is expressed as percentage of the vacuum oven dry solids value, permits a reasonably accurate estimate of the sucrose content of sweet sorghum juices and processing fractions, since juices from mature stalks have been found to contain a relatively small quantity of levulose as compared to dextrose (13).

PROCEDURES

Information noted in the literature cited earlier, and that obtained at Weslaco from the extensive analyses of several hundred raw sweet sorghum juice samples provided by various field studies, suggested several facts regarding the processing parameters which should be considered in practical starch removal: (1) the starch content of raw juices obtained from millable stalks may range from 0.5% to over 4% of the juice solid matter and the starch granules vary greatly in size; (2) some granules will be found in juices extracted by diffusion although the quantity will be much smaller than that extracted by intensive milling; (3) complete elimination of starch is desirable but from a practical standpoint, approximately 60°C. to avoid gelatinization of the starch granules; (5) starch elimination should be achieved as soon after juice extraction as possible so that higher processing temperatures can be employed for the control of sugar degradative action by bacteria, invertase, and the like; (6) centrifugal removal of starch should be avoided if possible because of the cost of the equipment and its maintenance; (7) the use of enzymes such as pancreatin to eliminate starch should be avoided if possible because of the cost of these materials and the problems associated with their efficient use; (8) high pH levels during processing should be avoided because reducing sugar contents of the sorghum juices frequently amount to 4% or more of the juice solid matter; (9) the first procedures to be explored should be those adaptable to conventional sugar cane operations insofar as is possible since equipment suitable for small scale juice extraction and processing is available.

Consideration of these facts suggested that a practical approach to the problem of starch elimination would be to determine whether suitable conditions might be found for settling starch from the raw juice in a manner similar to that employed in defecating sugar cane juice. A finely divided floc had been observed to form when sufficient alkali was added to produce a raw juice pH in excess of 7, but in order to attain a clumping of this floc which would efficiently trap the starch granules, to settle the coagulated material with a reasonable period of time and provide a starch-free clarified juice of good quality and a well compacted mud, careful evaluation of the effects of each variable must be made.

Suitable aliquots of a raw juice were measured out, juice density adjusted if necessary, alkali added to produce the desired pH, and the juices heated to the selected temperatures. After the heated materials were transferred to glass settling jars, flocculating agents were added if desired and the contents of the jars allowed to settle for one hour. Sediment volumes were noted at regular intervals and visual observations made of the colors and clarities of the clarified juice layers. After settling for an hour, the clear upper layers were removed for analysis. The purities and starch contents of the raw and clarified juices were then compared. Similar procedures were employed in defecting 20 liter portions of juice so as to provide sufficient material for evaluation of syrups.

From an extensive testing program conducted with a variety of raw sweet sorghum juices, optimum operating conditions were established for eliminating more than 95% of the starch during clarification of the raw juices. The effects of varying the selected ranges of pH, temperature, and density were also determined and verified by changes in juice composition. The selected parameters for starch elimination and the effects of changes in these operating variables are described below as abstracted from earlier disclosure of these procedures (9):

1. Juice density. Optimum performance was attained with juice densities which did not exceed 16° Brix. When juice densities exceeded 16°Brix, the rate of settling of muds was slow and the percentage of starch eliminated was poor. Mud filtration was also somewhat slower at higher juice densities.
2. Juice pH. Optimum performance was obtained in the range of 7.7 to 7.9 pH by addition of milk of lime or mixtures of calcium and magnesium hydroxides. Other bases, such as sodium or potassium hydroxide, produced a floc which settled out of the juice satisfactorily but the purities of the clarified juices were lower and the ash contents of the clarified juices were higher than when calcium and magnesium hydroxides were used. At pH levels of 7.0 to approximately 7.6, the reddish colors noted in many sorghum juices were less intense than at higher pH levels, but the starch granules were not efficiently trapped and settled with the muds, apparently because of the reduced quantity of sediment or muds which were available for this purpose. The lower purities of the clarified juices when liming was limited to 7.0 to 7.6 probably resulted from the smaller quantity of raw juice non-sugar matter which settled out as muds. At pH levels exceeding 7.9, somewhat higher juice purities were realized than were noted when liming

was limited to the 7.7 to 7.9 pH range, but the red colors extracted from the bagaccilo or plant residues in the raw juices greatly increased above pH 7.9 and became definitely objectionable at pH levels above 8.0. Clarified juices of 7.0 to 7.3 pH were obtained when the raw juices were limed to 7.7-7.9 pH.

3. Temperature. Optimum performance was noted at temperatures in the range of 55°-60°C. At temperatures below 50°C, the quantity of muds was reduced and the resulting clarified juice purity was lower than when the raw juices were heated to the 55°-60° range. Also the rate of mud settling was much slower. At temperatures exceeding 60° C, a portion of the larger, more fragile starch granules was gelatinized. At a temperature of 65°C approximately 10% of the starch present was gelatinized and therefore could not be removed during defecation.

4. Flocculating agents. A number of chemical additives were examined, and the general types described by their manufacturers as "high molecular weight polymers of the anionic type," such as Rohm & Haas Company's [3] Primafloc A-10, or Dow Chemical Company's Separan AP-30, or a high molecular weight pectate compounded with cellulose, such as Sunkist Grower's Pectate Pulp, performed satisfactorily in clumping the finely divided floc into larger particles which effectively trapped the starch granules and settled out of the juice in a reasonable period of time. The quantity required was found to

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[3] Use of a company and/or product name by the Department does not imply approval or recommendation of the product to the exclusion of others which may also be suitable.

range from 3 to 5 ppm based on the weight of juice. Satisfactory coagulation of the finely divided floc in the raw juice, and efficient trapping and elimination of the starch were not attainable without the use of a flocculation agent, although some raw juices appeared to clarify to a limited degree without the use of such an additive.

Twenty-one runs using 20 liter portions or raw juice were made according to the preferred operating conditions noted above. The analytical data from these runs are presented in Table 1. The free acidities of these raw sorghum juices ranged from 1.0 to 1.5% on juice solid matter, approximately double that of normal sugar cane juices. The mud volumes in these tests averaged 35.4% of the volumes of the raw juices processed, and the dry solids in muds averaged 6.5% on raw juice solid matter, obviously a major factor affecting the purity rise. The clarity of the defecated juices averaged 43% T as measured on the Luximiter. The indicated elimination of 97.2% of the starch and 20.8% of the protein while the carbonate ash increased by 0.8% suggests that the defecation procedures employed accomplished a reasonable removal of non-sugars and avoided any significant increase in the mineral content of the juices. The purity rise of 4.3 points is large according to sugar cane experience, but is reasonable in view of the quantity of non-sugar solids removed.

Examination of the clarified juices from these experiments revealed the presence of quantities of very small starch granules which had settled out on standing. As the starch-iodine colorimetric method for measuring starch cane juices had been found by Cashen and Friloux (3) to provide values which were variably less than the starch measured by other methods, comparisons were made of the starch contents of various raw and clarified sorghum juices, syrups, sugars, and muds as determined by iodine and by the phenol color method of Dubois, and the differences in the measured starch contents were greatest in clarified juices, syrups, and sugars, where the level was known to be low. When the phenol method of Dubois was applied to raw and purified sweet sorghum starch, values were obtained which approximated the dextrose content of the hydrolyzed materials measured by the Lane-Eynon method. From these studies it seemed apparent that the starch remaining in the clarified juices, as measured by phenol color, was approximately 0.1% on juice solids rather than the 0.04% noted in Table 1. Since this amount was considered excessive in materials from which sugar was to be crystallized, procedures were investigated for removing additional quantities of starch.

SEMI-SYRUP CLARIFICATION

Efforts to remove additional quantities of starch by re-clarifying the once defecated juices at the same densities and by the same procedures described earlier were not successful. However, when these juices were evaporated to syrups of 20 to 40° Brix, small quantities of finely divided floc were noted, suggesting that various processing conditions be explored in an effort to coagulate this floc, trap the starch, and settle out both starch and flocculant matter in a manner similar to that employed in raw juice defecation. Optimum conditions for this semi-syrup clarification and starch removal are noted below, as abstracted from an earlier disclosure of these procedures (10):

1. Syrup density. Best performance was obtained with semi-syrups between 20 and 45° Brix. In syrups of less than 20° Brix, the floc does not clump or settle effectively and rapidly. At solids levels higher than 45° Brix, conditions are occasionally favorable for the co-precipitation of insoluble dicalcium magnesium aconitate.

Where this salt precipitates with the starch and other non-sugars, its recovery and purification becomes more difficult.

2. Syrup pH. Best performance was obtained at a pH of 7.4-7.6, since maximum flocculation is attained in this range. At lower pH levels, inferior starch eliminations were noted, and at higher pH levels syrup colors were darker, with no improvement in the degree of flocculation or starch elimination.
3. Temperature. When starch elimination during raw juice defecation had been adequate, and not more than approximately 0.08% starch on juice solids remained in the clarified juice, temperatures slightly higher than 80° C have been employed without danger of gelatinizing the starch granules. However, essentially the same percentage elimination of starch and other non-sugar solids was attained at temperatures of 70° to 80°C. Temperatures in the range of 60° to approximately 70°C did not provide as efficient eliminations of starch and protein as were noted at 70°-80°C.
4. Additives. The addition of approximately 1 to 2 ppm of a flocculating agent similar to that employed in the raw juice defecation was found necessary to provide adequate coagulation and rapid sedimentation of the flocculant materials from these semi-syrups. Since the formation of calcium phosphate flocs is an essential factor in both raw juice defecation and semi-syrup clarification, an adequate supply of available phosphate must be present in both raw juices and semi-syrups to insure satisfactory clarification and starch elimination.

A deficiency of phosphate in juice or semi-syrup can be supplied as phosphoric acid, added in either case before adjustment of the pH with lime. A simple test has been devised to detect the lack of sufficient phosphate in the raw juice for satisfactory defecation, a circumstance which appears to indicate a need for addition of some 80 ppm of P_2O_5 as phosphoric acid to the semi-syrup as well. In the measurement of the free acidity of the raw juice, standard alkali is added to provide a pH of 8.3. At this point about 1 ml of a 0.05% solution of flocculating agent is added before stirring is stopped. After settling for 30 minutes time, the presence of a heavy flocculant precipitate in the juice, which amounts to 25 to 30% by volume of the raw juice, indicates the presence of adeuqate phosphate for both raw juice and semi-syrup clarification. A sediment volume of 20% or less indicates a phosphate deficiency. Some 200 to 300 ppm of $P_2O_5$are required in satisfactory defecation of raw juices, but deficiencies noted in juices from various areas have not usually indicated the need of more than an additional 100 ppm.

Analytical data are provided in Table 2 to indicate the changes in composition which occurred as the result of juice defecation followed by clarification of the product syrups. These are averages of data obtained from 6 experiments conducted with 15 to 20 liter lots of various raw sweet sorghum juices. Both raw juice and semi-syrup clarifications were made according to the preferred processing conditions previously described. In these tests the clarified juice fractions which were concentrated to semi-syrups contained both the clarified juice siphoned from the muds and that which was filtered from the muds. These combined clarified juice fractions were concentrated at low temperatures and under high volume to 30-35° Brix semi-syrups for syrup clarification.

Syrup sediments or muds settled more rapidly than the juice clarification muds, occupied a volume too small for accurate measurement, and consisted of solid matter which, when washed to approximately 2% total sugars, represented 0.1 to 0.5% of the syrup dry solids content. Semi-syrup clarities were from 70 to 80% of the values measured on the clarified juices. The data in Table 2 show an apparent drop in purity between clarified juice and clarified semi-syrup. Purities of the clarified juices were obtained from the juices siphoned from the muds only. A slightly lower purity was frequently encountered in the clarified juices filtered from the muds, doubtless as a result of delays encountered in handling these materials on the filtering equipment available. When the two clarified juice fractions were mixed for concentration, the purity of the mixture was at times less than that reported for the siphoned juice. In the course of semi-syrup clarification, little increase in sucrose or reducing substances would be anticipated on the basis of the small quantity of non-sugars eliminated in this operation. Comparative starch analytical data presented in this table show clearly that the two methods of analysis employed do not measure the same material, and emphasize the need of a procedure of greater accuracy than that used by Balch (1) when very small quantities of starch or very small, immature starch granules are to be measured. It is also to be noted that the raw juice starch contents averaged in Table 2 are doubtless much lower than those averaged in Table 1. There is a wide variation in the starch content of raw sweet sorghum juices grown in different areas and during different years. Juices containing more than 3% starch as measured by phenol color have been successfully processed to clarified semi-syrups with less than 0.04% starch.

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SUMMARY

Suitable conditions have been developed for practical elimination of starch from sweet sorghum juices and semi-syrups while at the same time achieving clarification of these materials. These procedures are adaptable to raw cane sugar operations, requiring two defecation steps to effect removal of 97% of the raw juice starch content. Maximum efficiency requires rather careful control of pH, density, temperature, and the use of a flocculating agent in each defecation procedure. Examination of these processing parameters during continuous-type operations on a pilot plant scale, and followed by crystallization of raw sugar is a necessary extension of this research program to determine the potential of the sweet sorghums as a supplementary sugar crop.

Table 1. Composition of sweet sorghum juices before and after defecation. [1]

	Dry solids purity	Reducing substances	Starch[2]	Carbonate ash	Protein
Raw juices	77.3	5.08	1.43	6.27	2.83
Clarified juices	81.6	5.37	0.04	6.32	2.24
Change, points	4.3	0.29	1.39	0.05	0.59

[1] Average data from 21 experiments.

[2] Starch determined by starch-iodine color.

Table 2. Changes in composition of sweet sorghum juices during raw juice defecation and semi-syrup clarification. 1/

	Dry solids purity	True purity	Reducing substances	Carbonate ash	Starch, by		Clarity (% T)
					iodine method	phenol method	
Raw juice	78.5	78.00	5.36	6.94	0.93	1.72	--
Clarified juice	81.8	81.18	5.62	7.06	0.028	0.064	57
Clarified semi-syrup	8.12	80.93	5.77	7.01	0.008	0.024	45

1/ Average data from 6 experiments

REFERENCES CITED

1. Balch, R. T. Sugar J. 15(8): 11, 12, 14, 15. 1953.
2. Bryan, A. H., and Sherwood, S. F. USDA Farmer's Bulletin No. 1389. 1923.
3. Cashen, N. L., and Friloux, J. J. J. Agr. Food Chem. 14: 434-437. 1966.
4. Coleman, O. H., Cowley, W. R., Broadhead, D. M., Freeman, K. C., and Stokes, I. E. ARS Bulletin 34-72, U. S. Department of Agriculture. 1965.
5. Cotton, R. H., Norman, L. W., Rorabaugh, R., and Haney, H. F. Ind. Eng. Chem. 43: 628-635. 1951.
6. Dubois, M., Gilles, K. A., Hamilton, J. K., Rebers, P. A., and Smith, F. Anal. Chem. 28: 350-356. 1965.
7. Poe, W. E., and Barrentine, B. F. J. Agr. Food Chem. 16: 983-984. 1968.
8. Sherwood, S. F. Ind. Eng. Chem. 15: 780-784. 1923.
9. Smith, B. A., U. S. Patent No. 3,442,704, issued May 6, 1969.
10. Smith, B. A., U. S. Patent No. 3,442,856, issued Sept. 2, 1969.
11. Ventre, E. K. Sugar J. 3(7): 23-30. 1940.
12. Ventre, E. K., Ambler, J. A., Byall, S., and Henry, H. C. U. S. Patent No. 2,359,537, issued Oct. 3, 1944.
13. Ventre, E. K., Byall, S., and Catlett, J. L. J. of Agr. Research 76: 145-151. 1948.
14. Walton, C. F., Jr., Ventre, E. K., and Byall, S. USDA Farmer's Bulletin No. 1791. 1938.

15. Wiley, H. W. Report of the Commissioner of Agriculture for the Year 1883.

16. Wiley, H. W. Report of the Commissioner of Agriculture for the Year 1884.

17. Wiley, H. W. Bulletin No. 5, Chem. Div., USDA, 1885.

18. Wiley, H. W. Bulletin No. 14, Chem. Div., USDA, 1887.

19. Wiley, H. W. Bulletin No. 18, Chem. Div., USDA, 1888.

20. Wiley, H. W. Bulletin No. 20, Chem. Div., USDA, 1888.

21. Wiley, H. W. Bulletin No. 29, Chem. Div., USDA, 1891.

22. Wiley, H. W. Bulletin No. 34, Chem. Div. USDA, 1892.

23. Willman, J. J., and Davison, F. R. Ind. Eng. Chem. 16: 609-610. 1924.

TRASH

Octave Gutekunst
Vice President and Manager
St. John Factory
St. Martinville, Louisiana

The handling of trash is a costly proposition for all concerned. The grower would never dream of deliberately adding a half ton weight to each small cart to make the trip from the field to the factory and return. Yet this added weight with its attendant cost in fuel, wear and tear, etc. becomes a burden when the trash analysis indicates only 5.5%. In most instances, the factory is not paying for carrying this freeloader, but it is paying for finding out its presence. From two to five extra men are employed for sampling and testing trash alone.

The mill engineer doesn't need to wait for the results from the trash lab to know what is coming in. The load of cane drops on the feeder table in a cloud of dust. What to do? At present, the simplest method is to wash the load of cane. Simple? Well, some mills have a few nozzles spraying water on the carrier, but this isn't too efficient when the cane doesn't have a chance to drain and dry before being cut-up by the knives. So, a more elaborate arrangement of split feeder tables is needed to spread the bundle of cane so that the water can be effective when sprayed on and the wash-off can then be drained to a pit where a pump can move the dirty water onto a pond of fifty to one hundred and fifty acres where it can be stabilized. It may take one pump or three pumps with one thousand G.P.M. capacity or up to five thousand G.P.M. capacity to handle the washing system. In its own way, this cleaning process can be very expensive, but when evaluated against possible losses if not used, any attempt at cleaning seems feasible.

In 1950, a study at LSU showed that for each one percent of trash on gross cane delivered, the processor suffered a loss due to lowered mill capacity, higher sucrose losses, increased labor costs, and other measurable items equivalent to 1.85% of the value of the cane ground. At the present price of cane, that means about fifteen cents per ton for each one percent of trash. At 5% trash, the loss of the industry is about seventy-five cents for each ton. These figures are presumed to be conservative.

From the engineer's point of view, the mill loses because of the wear on the knives and carrier equipment. Before washing, carrier chains lasted up to fourteen years with one rebushing and pin change. Now, a chain needs repairs every other year and replacement possibly every four. Juice pumps, valves, screens, and piping have all worn out quicker since trashy cane became prevalent. Mill rolls that used to take off thirteen to fifteen crops have to be reshelled in four years. Mud accumulates in the juice tanks, more ashes on the furnaces, it is harder to burn the bagasse - the engineer has problems.

The superintendent finds that grinding uncleaned mechanically harvested sugar cane means poor clarification of the juice, increased fouling of heating surfaces, higher juice viscosity due to "gums," and an excess of sand and other inert matter all of which tend to reduce boiling capacity and increase ash in sugar.

Everyone feels that trash is harmful; attempts have been made at various times to put a dollar value on just about every loss that could be attributed to trash. Even the people wanting to use our bagasse for furfural production want to consider the effect of trash.

What is trash? The 1944 Cane Price Determination defined it as "All cane must be reasonably free from shucks or trash and must be sound, unfrozen, and merchantable, and cut to the reasonable satisfaction of the processor. The cane must be cut at the top ripe joint unless and until there is a freeze, after which knives shall be lowered so as to remove all sour or acid joints." The 1969 Cane Price Determination: "'Trash' means green or dried leaves, sugarcane tops, dirt, and all extraneous material delivered with sugar cane."

A technical committee defined merchantable cane for the purposes of the trash determination as: cane which is free of dirt, leaves, roots, suckers, loose tops, and other extraneous material and topped at the last hard joint.

The 1969 Sampling, Testing and Reporting Procedures call for performance of the following:

1. Remove leaves and sucker, if any from the stalks.

2. Remove loose sugarcane top (i.e., that portion of the cane which is removed by topping in the field.)

3. If any sugarcane included in sample has not been topped or has been topped above the last formed joint, remove all growth above the third last formed joint from the bud.

4. Remove also the roots and all other growth below the ground level mark.

Item three of the preceding paragraph sounds good until one realizes that the bud is usually followed by one or two forming joints of one-sixteenth inch spacing and two or three formed joints of one-eighth inch to one-fourth inch spacing; so topping knives positioned at the third last formed joint from the bud can be twelve to eighteen inches above the last hard joint. This is quite a quantity of non-sucrose-bearing cane to be considered non-trash.

REFERENCES

1. Keller and Schaffer, 1951 - "The Effect of Cane Trash on the Milling Operation," Engineering Experiment Station Bulletin #25.

2. A. L. Sebre; Sugar-Azucar, November, 1958.

3. W. S. Daubert; "The Cost of Trash to the Sugar Factory," ASSCT, February 12, 1948.

WASTE CONTROL IN THE LOUISIANA RAW SUGAR INDUSTRY

John J. Seip
Audubon sugar factory
Louisiana State University
and A. & M. College
Baton Rouge, Louisiana

SUMMARY

While detection and control of raw sugar factory wastes are handled and supervised by the factory technical personnel, the final responsibility is that of the factory management. Thus while this paper deals with the technical aspects of waste control, every effort has been made to present it in as non-technical a manner as possible.

In this paper the basic state and federal regulatory control is summarized. Additionally, common terms are defined as dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), oxygen consumed (OC), parts per million (ppm), and population equivalent - as well as miscellaneous waste water criteria as total, fixed, volatile, suspended, and settleable solids.

In a simple tabulation, the various raw sugar factory wastes are identified and quantified on a 1,000 tons cane per day basis, and some calculations are demonstrated. Some aspects of biochemical waste stabilization are discussed - to include aerobic and anaerobic reactions.

The specific waste streams are reviewed in detail to include variations in volume and degree of contamination, and measures for control and handling the streams are suggested. These waste streams include condenser water, floor washings, heating surface cleaning solutions (soda, acid, and rinse water),

filter cake, accumulated fly ash, boiler blowdown, sweet water from the intermediate evaporator effects and yard drainage.

Particular attention is given to the subject of cane wash water - and current methods of handling the effluent.

Separate sections deal with routine laboratory analysis and the prospects of accelerated biostabilization of cane wash water such that a "closed loop" system may be possible. Research work at LSU covering the biostabilization of sugar solutions is reviewed - to include the mechanism of the reaction and the variables which affect the rate of reaction.

Several devices for "adding" oxygen to a cane wash water stabilization system are discussed, and the need for pilot scale studies in this area is stressed

Some problems of air contamination are discussed. Unfortunately, because of time limitations, this subject is only briefly touched upon.

STATE AND FEDERAL CONTROL

State control of waste water quality is executed by the Louisiana Stream Control Commission. The Louisiana raw sugar factories operate under an Order "--relative to the discharge of wastes from sugar mills located in the State of Louisiana."

Recently the federal government has entered the picture by way of the Federal Water Pollution Control Act (FWPCA) of 1965. The federal act may impose standards which must be incorporated into the state control regulations.[7]

SOME DEFINITIONS

Dissolved Oxygen (DO): Dissolved Oxygen (DO) is the amount of oxygen in solution in water. The maximum solubility in water is strongly temperature dependent as shown in the following tabulation:[18]

Solubility of Oxygen in Water

Temperature °C	Temperature °F	Dissolved Oxygen, ppm
0	32	14.6
20	68	9.2
50	122	5.6

As will be shown later, while the oxygen "holding" potential of the water decreases with temperature, the biochemical reaction rate increases with temperature.

A recent directive of the FWPCA includes provisions with regard to Bayou Teche that:[6]

> "Dissolved oxygen concentration of not less than 50% saturation at existing temperature (must be) maintained in the stream."

Biochemical Oxygen Demand (BOD): The stabilization or biodegradation of sugar in factory wastes proceeds by means of microorganisms which consume the sugar (and other organic substances in the stream) as a source of energy - utilizing oxygen in the reaction. Properly, the reaction proceeds aerobically, i.e., in the presence of free oxygen in the water.

The biochemical demand (BOD) of a sample of waste water is a measure of the amount of biodegradable (sometimes called putrescible) material in the stream. The BOD test is a measure of the amount of oxygen consumed in a given time by a given strength of waste effluent under specific temperature conditions. Pending on the time of the test, it may measure not alone biodegradable carbonaceous material as sugar, but nitrogenous material as well.

While complete aerobic stabilization of a waste stream may take as long as 100 days, the common test period consumes five days and the procedure is sometimes referred to as the BOD^5 test.

Tests on sugar refinery wastes at 20°C have shown that 60 to 70% of the biodegradable carbonaceous material is stabilized in the 5 day test period

- with essentially complete stabilization in 20 days. After 8 to 10 days, oxidation of nitrogen compounds which may be present begins - and continues to completion in 20 to 21 days.[2]

Chemical Oxygen Demand (COD): The chemical oxygen demand (COD) is the oxygen required to stabilize *all* carbonaceous material - both biodegradable as sucrose - as well as cellulosic material as bagacillo.

The COD *test* procedure is commonly used for determining the total carbonaceous material in the waste stream. It is a chemical technique involving digestion with potassium dichromate and sulfuric acid - and refluxing. Considerable precision is required in making up the test solutions and running the tests; however, the test can be completed in two to three hours in contrast to the 5 day BOD test.

Another means for determining the total carbonaceous material in the waste stream is the oxygen consumed (OC) test. Here the digestion is by means of potassium permanganate and sulfuric acid. The test procedure, which is considerably simpler than the COD test, has been used in research work at the Audubon Sugar Factory and has been adopted recently by several Australian sugar factories for routine waste water chemical control.

Tests comparing the *difference* of COD and OC between sugar factory incoming and effluent waste streams have shown reasonably good correlation with BOD tests run on the same streams. That is to say that the Δ or incremental change in COD and OC compares favorably with the Δ or incremental change in BOD over the sugar factory.

Parts Per Million (ppm): This figure implies a weight ratio. Thus 20ppm would be interpreted as 20 parts, pounds, tons, etc., per 1,000,000 parts, pounds, tons, etc. Since it is quite commonly converted to pounds per hour, day, etc., it is useful to view it in a ratio form such as: $\frac{20}{1,000,000}$

When dealing with industrial waste of high specific gravity, the figure mg/l (milligrams per liter) is commonly used - with the specific gravity stated. Obviously, with a specific gravity of one, ppm and mg/l are the same.

Total Residue, Settleable Material, etc.: Factories which have submitted Status Reports to the Stream Control Commission have had occasion to deal with the following waste water terms which are defined below in terms of their basic analytical technique:[18]

Solids	Determined by
A. Total Residue	Evaporation at 103°C
B. Total Fixed and Volatile Residue	Ignition (ashing) at 600°C for fixed residue - and volatile residue calculated by difference.
C. Total Suspended (Non-filterable) Residue	Filtration
D. Fixed and Volatile Suspended Residue	Ignition as B for fixed residue and volatile residue by difference.
E. Dissolved (Filterable) Residue	Calculated by difference as A minus C - or evaporation of filtered sample from C.
F. Settleable Matter	Sedimentation in an Imhoff Cone.

Population Equivalent: One statistic commonly used is the population equivalent of a 24 hour BOD load discharged into a stream. This is based on the 24 hour sanitary sewage demand of one person - or the per capita per day sanitary sewage demand. A figure of 0.17 pounds BOD per person per day is commonly used.

RAW SUGAR FACTORY WASTES

The following two primary factors make control of the typical raw sugar factory liquid and semi-liquid wastes difficult:

1. The large volume of water used by the typical factory.
2. The fact that the major waste constituent is sugar - a carbohydrate which naturally stabilizes through the mechanism of biooxidation.

The following factory survey data averages for the period 1954 through 1956 have been factored to 1,000 tons cane per day.[9] Where the quantity and composition of the waste stream is unknown or questionable, no quantitative data are indicated.

	per 1,000 Tons Cane per Day		
		5 day BOD	
Waste	gpm	ppm	lbs/24 hours
Cane Wash Water	416-832	680-340	3,400
Condenser Water	2,000	69	1,653
Floor Washings and Boiler Blowdown	42	378	189
Cleaning Soda, Acid, and Rinse Water	4.2	-	16.5
Excess Condensate	20.9	10	2.5
Filter Cake	-	206,000	3,230
Accumulated Fly Ash	-	-	-
Yard Drainage	-	-	-

At this point it is well to emphasize two factors:

1. The above data represent averages from several factories which were investigated.
2. During the grinding season, only the condenser water may enter public waters - provided it meets specific standards.

SOME SIMPLE CALCULATIONS

The annual Louisiana Stream Control Commission reports which cover the Louisiana raw sugar industry use the term ppm to denote the biochemical oxygen demand (BOD) of the factory effluent into a public stream and the dissolved oxygen (DO) at specific points in the stream.

A question might arise as to how we arrived at the 5 day condenser water BOD load of 1,653 pounds per 24 hours. Quantitative data for this calculation includes the volumetric flow rate of 2,000 gpm and 69 ppm BOD^5 (5 day BOD). The calculation is simplified by the following identity:

$$\frac{\text{ppm BOD}^5}{1{,}000{,}000} = \frac{\text{lbs BOD}}{\text{Total Pounds}}$$

Total pounds in this case is the 24 hour load from 2,000 gpm (at 8.32 pounds/gallon) times 60 minutes per hour times 24 hours per day - or 23,961,600 pounds.

Converting 69 ppm to pounds BOD per day involves substituting 69 ppm BOD^5 and completing the calculation as shown below:

$$\frac{69}{1{,}000{,}000} = \frac{\text{lbs BOD}}{23{,}961{,}600}$$

or

$$\text{lbs per day} = \frac{69 \times 23{,}961{,}600}{1{,}000{,}000} = 1{,}653$$

COMMENTS ON BIOCHEMICAL WASTE STABILIZATION

With raw sugar factories, waste stabilization is primarily a biochemical reaction - the prefix bio denoting a chemical reaction occurring by means of, or in the presence of, microorganisms. The reaction may be aerobic (in the presence of oxygen) or anaerobic (without oxygen).

Aerobic Oxidation: In its simplest form, aerobic oxidation may be expressed by the following chemical reaction:

$$C_{12}H_{22}O_{11} + H_2O + 12O_2 \xrightarrow{*} 12CO_2 + 12H_2O + \text{Heat}$$

	sucrose	water	oxygen	carbon dioxide	water
MW	342		384		
lbs	1		1.125		

*Reaction conditions: Micro-organism, nutrients, temperature.

The above chemical "shorthand" indicates that one pound of sucrose (molecular weight 342) reacts with 1.125 pounds of oxygen (384 molecular weight) in the presence of the proper microorganisms, sufficient nutrients as nitrogen, proper temperature conditions, and obviously adequate oxygen. Under these circumstances the reaction proceeds to complete stabilization with the final products of carbon dioxide, water, and the evolution of heat.

Technically, the complete reaction is more complicated than indicated above and involves the three stages of (1) oxidation, (2) cell (microorganism) synthesis and (3) cell respiration.

Under conditions where there is an inadequate volume of water into which to discharge the waste stream - or the dissolved oxygen in the available volume of water is too low - we may have conditions where the dissolved oxygen content of the stream is inadequate to support aquatic life - or the reaction may proceed under anaerobic conditions.

Anaerobic Oxidation: Lacking available dissolved oxygen in the stream, the reaction may still proceed, but some of the oxygen is taken from chemicals in the stream such as sulfates or nitrates. In the case of sulfates, the reaction might be expressed in the following form:

$$\underset{\text{sulfate ion}}{SO_4^{--}} + \underset{\text{carbon ions}}{2C^{----}} + \underset{\text{hydrogen ions}}{2H^{+}} \longrightarrow \underset{\text{hydrogen sulfide}}{H_2S} + \underset{\text{carbon dioxide}}{2CO_2}$$

The above half reaction (ions are used in part of the reaction) shows that carbon and hydrogen ions have taken their oxygen from the sulfate ions. One of the products is hydrogen sulfide with its offensive rotten egg odor. Other nuisance products may include methane, ammonia, organic acids, etc. Such anaerobic reactions must be followed ultimately by aerobic conditions to complete the stabilization.

CONDENSER WATER

State regulations currently permit the discharge of condenser water to public streams providing (1) that not more than 50 ppm of BOD is added to the water and (2) the dissolved oxygen (DO) is maintained at not less than 1/2 of its saturation value at the existing temperature of the receiving stream.

Depending on the factory capacity, condenser water requirements may range from 4,000 to 12,000 gpm (equivalent to 6 to 17,000,000 gallons per day per factory).

Surveys among factories have shown BOD's ranging from 10 to 450 ppm. At the upper limit, the factory is incurring losses in recoverable sugar of the order of $600 per 1,000 tons of cane per day.

With proper precautions, BOD levels of 20 to 40 ppm can be maintained. Obviously financial considerations alone warrant steps in this direction.

Barometric leg-type condensers serve the:

1. Evaporators
2. Pans
3. Rotary drum mud filters

Some expedients to minimize BOD in condenser water include:

1. The survey and mapping of condenser water canals - both within the factory and from the factory to the receiving stream or basin.

2. Properly revetting the condenser canals to block the entrance of contaminated streams.

3. Providing accessible sample outlets on the barometric legs for sucrose determinations.

4. Properly sized, installed, and periodically inspected entrainment separators.

   The evaporator entrainment separators should be supplied with external drain lines of adequate size and equipped with sight glasses for visual verification of the separator performance.

   The separator drain lines should terminate either (1) in the bottom of the effect or (2) above the top tube sheet by way of a U-type loop. These provisions are necessary to prevent the vapors by-passing directly up through the drain lines into the overhead vapor line.

5. Evaporator level and pressure control devices should be provided to minimize liquid surges which could contribute to entrainment.

6. Maintaining a proper operating level in the evaporators and a proper final strike level in the pans will minimize entrainment.

7. The muds filter vacuum system may be subject to surges - resulting in entrainment into the condensers. Knockout pots in the line to the condenser may be necessary.

8. Because of factory expansion, some sections of the boiling house may be operating well below design capacity. In cases such as this, particular steps should be taken to determine evidences of entrainment.

9. Obviously, proper equipment operation and supervision are essential.

FLOOR WASHINGS

This item includes mill bearing water and washings from the mill floor; mill and boiling house pump leakage; spillage of juice, syrup, molasses; and residue from factory wash out operations.

The BOD level of these streams may vary from 200 to 2,000 ppm.[13] State law stipulates that this material and most of the remaining waste streams be impounded during the crop and only discharged into public streams after they have stabilized.

Control measures include the following:

1. Survey and mapping of all in-factory and out-of-factory drainage facilities.
2. Daily record of unusual spills.
3. Separation of canals carrying contamination and uncontaminated material.
4. Close factory supervision.

Isacks discusses methods for impounding floor washings at Southdown in the article "Nature and Disposal of Cane Sugar Factory Waste in Louisiana."[10]

The canals to the detention basin should be provided with oil skimmers to permit separation of oil from the main stream.

EVAPORATOR, PAN, AND HEATER WASHOUT

This item includes the "blowdown" from the soda ash tank for the evaporator, pan, and heater cleaning - as well as the subsequent rinse water, and the spent acid and acid rinse from the evaporator cleanout. Obviously, any means to reduce the frequency of evaporator, pan, and heater cleanout would minimize the volume of such waste.

By law, this material must be impounded during the grinding season, and released as it stabilizes. The article by Isacks (noted above) also discusses impounding requirements for these streams.[10]

FILTER CAKE

With mechanically harvested and handled cane - and the rotary vacuum mud filters, filter cake averages about 4% on cane (80 pounds per ton of cane). The sucrose content of the cake normally runs between 3 to 4% on cake. As discharged from the rotary vacuum filter, this cake has a moisture content of about 70%.

Current methods for handling this material include:

1. Scrolling the cake to a silo from which it is discharged to trucks for transportation to the fields for field dressing or for sanitary land fill.
2. Slurrying the material - in which case it must be impounded during the grinding season. Obviously, with the roto belt type filter, the slurry water may be the filter cloth wash water.

Needless to say, the BOD content of this material is high - as is the total solids. The latter is about 16 tons per 1,000 tons of cane per day - of which about 60% is volatile and 40% is fixed solids.

FLY ASH

With properly disigned and operated fly ash separators, this source of air pollution should be minimal. Precipitated fly ash may be trucked off the factory site as land fill, or it may be slurried with the filter cake to an impounding area.

BOILER BLOWDOWN

This may approximate 5 to 10% of the total volume of boiler feed. While low in BOD it is obviously high in inorganic sludge and soluble solids. Such material should be impounded.

SWEET WATER (EXCESS CONDENSATE)

An obvious expedient for minimizing factory effluent contamination is to reduce the volume of water entering the factory. Under normal conditions, the volume of sweet water from the evaporator effects - plus the steam condensate - is more than adequate for the factory process water requirements.

With the above in mind, sweet water is a prime prospect for boiler makeup, dilution of molasses, washing of sugar in the cintrifugals, and washing down the mills. In some cases it may be cooled and used directly as maceration water on the mills - or mixed with cold process water.

With proper control for contamination of sweet water, excess condensate should be low in dissolved solids and BOD - and as such should provide no disposal problem other than that of thermal pollution.

YARD DRAINAGE

Mangled cane in the yard may be a severe source of pollution during rain - or if the yard is frequently washed - and there are no provisions for channeling the yard run-off into the proper waste disposal system. A high degree of contamination may also be encountered if the cane is washed in the carrier close to the knives where the drainage includes both wash water and juice.

CANE WASH WATER

Cane wash water poses a particular problem because of the large volume of water involved, the usually high BOD content of the effluent, and the need for impounding the stream. The volume of wash water may vary from 500 to 1,000 gpm per 1,000 tons cane per day. Effluent BOD contents of 300 to 1,000 ppm have been recorded.

Information on the quality of wash water is limited. The following has been listed as typical:[9]

Component	ppm
Total solids	2,900
Suspended solids	2,104
Settleable solids	1,722

It is felt that several factors have contributed to problems of cane wash water contamination. Among these are bulk handling of cane and the design of some of the feeder tables. Considerable mangling of the cane has been observed with several chain net installations. Additionally, poor design of the leveler on the feeder table has resulted in additional mangling of the cane.

Handling Wash Water on a Once-Through Basis: Until recently, the typical cane washing installation involved transferring all of the wash water effluent into a lagoon system. Properly this consisted of two basins - the first for settling of the grit and sand, and the second for the biostabilization.

Recycle of Wash Water: More recently, several factories have employed the expedient of recycling as much as 50% of the total wash water requirements - bleeding on and off the remaining 50%. Ideally, such a system entails adding the fresh (make-up) water at the last washing stage - either on the feeder table just prior to entering the carrier, or as the cane breaks from the table into the carrier, or on the carrier (the least desirable location). The recycled water is added at the first or primary stage - generally on the feeder table.

Complete Recycle of Wash Water: The literature cites a case where a beet sugar factory utilizes a completely enclosed system where the wash water levels off at 3,300 ppm BOD. No problems were encountered until it became necessary to dispose of the water at the completion of the crop.[3]

A Possible System for Study: A totally enclosed loop is envisioned involving screening, sedimentation for sand and grit removal, and accelerated biostabilization to reduce the BOD level to that which would be tolerable for a sustained operation. The mechanics of biostabilization and the time elements involved are discussed in a subsequent section.

ROUTINE FACTORY LABORATORY ANALYSIS

The following typical sugar factory laboratory procedures are envisioned:

1. Dissolved oxygen (DO), temperature, and pH of the receiving stream.
2. Alpha napthol test for sugar in condenser and other waste water streams.
3. Oxygen consumed (OC) of the factory influent and effluent streams in order to determine the OC change over the factory.

When used properly, the alpha napthol test can be an accurate tool for control of stream contamination. In conjunction with a photoelectric colorimeter such as the B & L Spectronic 20 and standard sugar solutions, the results are quantitative.

The OC test has been used by Louisiana factories in the past and is currently being used by several Australian factories because of its simplicity and ready adaptability to the typical raw sugar factory personnel and laboratory facilities.

BIOLOGICAL STABILIZATION

Much work has been done at the Audubon Sugar Factory on biochemical studies of sugar cane waste water. The biological or biochemical stabilization process is a first order reaction of the form:

$$\frac{-dc}{dt} = kc$$

where: c is the concentration of BOD, COD, OC, etc.
t is the time
k is the reaction rate constant

The integrated equation may be rearranged in the following form in order to determine the reaction rate constant k by calculation or by graphical plotting:

$$k = \frac{\ln c_1/c_2}{t_2 - t_1}$$

where: The subscripts 2 and 1 represent the final and initial conditions of the reaction.

A common term to express the rate of reaction is the half-life which is the time to reduce the concentration (BOD, COD, or OC) to one-half of its initial value. This may be calculated as:

$$t_{1/2} = \frac{0.693}{k}$$

Depending on the experimental conditions, half-lifes ranging from 250 to 32 hours were observed.[16] Operating conditions or factors which affected the half-life were observed to be:

1. Amount of oxygen present: Sufficient oxygen must be available to insure aerobic conditions - and at a diffusion rate such that the rate of biological reaction is controlling and not the rate of oxygen diffusion.

2. Temperature: The higher the temperature the higher the rate of reaction. A rough approximation is that the reaction rate doubles for each 10°C increase in temperature.

3. Nutrient Addition: One part of nitrogen per 20 parts BOD, COD, or OC removed was recommended. In this experimental work, nitrogen was added as monobasic potassium phosphate (KH_2PO_4), amonium nitrate, and amonium hydroxide. Potassium and phosphorus did not significantly accelerate the reaction rate.[8]

4. Effect of Solids in the Waste: The ability of a waste stream to absorb oxygen is a function both of the soluble and insoluble material in the stream. This factor may be expressed as the alpha (OC) coefficient - which is the oxygen uptake of the actual waste stream divided by the oxygen uptake of water at standard conditions. Obviously, such data is best determined in pilot-scale studies.

5. Microorganisms: The microorganisms necessary for the reaction can be seeded in the stabilization apparatus - or they may naturally develop after a time lag. While many microorganisms will perform biostabilization, including yeasts, fungi, and bacteria, bacteria have shown the highest rate of metabolism. Certain toxic substances as acids and alkali can abruptly halt the biochemical stabilization. For this reason, close control of such processes is necessary.

In a biochemical process such as the above, initial treatment by screening the wash water should pose no problem.

It is expected that screening would be followed by sedimentation or settling for sand and grit removal. No rate data are immediately available for the design of such equipment.

Factory scale tests indicated that chemical costs were prohibitive for flocculation prior to biostabilization. In this case, flocculation entails the removal of colloidal or non-settleable material.

Devices to insure accelerated oxidation of the screened and settled wash water include:

1. Cascade Board: This was developed at LSU by Dr. A. G. Keller.[16] It is currently in pilot-stage investigation in Florida.

2. Jet Aeration: This involves the addition of oxygen by means of compressed air through spargers - well immersed in the lagoon area. This set up insures not alone oxygen addition but mixing of the waste stream and microorganisms. An excellent paper was presented on this possibility by a representative of the Penberthy Company at the 1970 Winter ASSCT meeting.[20] Although this prospect was considered for condenser water, it should be applicable equally to cane wash water service. Lagoon areas ranging from 0.3 to 5 acres were considered.

3. Floating Aerators: These devices are commonly used for cooling purposes as well as oxygen addition.

4. Packed Towers: A common type of packed tower for this purpose is the Flocor design which is marketed by the Ethyl Corporation. The plastic packing offers intimate surface contact between the wash water and circulating air. Additionally, the microorganisms develop a substrate on the packing surface.

What the industry obviously needs are pilot-scale studies of the above possibilities from which can be developed:

1. Initial cost data
2. Operating cost

Other Waste and Waste Treatment Possibilities: Filter cake may be amenable to special biochemical treatment methods which are currently being investigated at LSU.

AIR CONTAMINATION

The preceeding discussion of sugar factory waste water problems has left little time for comment of the subject of air contamination. This in itself could be the basis for a rather lengthy discussion. Briefly, raw sugar factory air contamination lies in the areas of:

1. Open burning of excess bagasse
2. Fly ash

Several factories have recently expanded their furnace capacities such that the factories are both steam generators and excess bagasse incinerators. Additional steps to improve furnace bagasse burning efficiency have included air pre-heaters. Furnace design and air pre-heaters have significantly reduced the volume of excess bagasse - or have eliminated this waste product completely.

Two factories are known to be investigating the possibility of acquiring incinerators for the sole purpose of burning excess bagasse.

Obviously, the possibility of designing the bagasse handling facilities to return unburned bagasse back to the furnaces during clean-out should not be overlooked.

With regard to fly ash, many Louisiana factories are located sufficiently close to residential areas to require fly ash arresters. Proper arrester design and proper furnace operation will go a long way to minimizing this problem.

LITERATURE REFERENCES AND A PARTIAL BIBLIOGRAPHY

1. Jorge Balsa, "Detecting Sugar Losses by Entrainment," Sugar y Azucar, November, 1967, p. 36.

2. G. S. Baumert, "Refinery Wastes and Pollution Control," 1969 Proceedings of the Sugar Industry Technologists, pp. 194 - 217.

3. Ronald Benton and James Fischer, "During Campaign and Post-Campaign Treatment of Recirculated Flume Water," 1970 Proceedings of the American Society of Sugar Beet Technologists.

4. Frank J. Coogan, "The Disposal of Waste," 1941 Proceedings of the American Society of Sugar Cane Technologists, pp. 64 - 78.

5. Louis Cusachs, "Industrial Wastes and Their Effect on Sewage Treatment Plants," Louisiana Water and Sewage Conference, Baton Rouge, Louisiana, 1947, pp. 112 - 114.

6. John D. Givens, "Report on Bayou Teche," Prepared for the Louisiana Stream Control Commission Meeting of November 26, 1968.

7. John D. Givens, "Bayou Teche - 1969 Grinding Season," Prepared for the Louisiana Stream Control Commission Meeting of December 11, 1969.

8. Houston K. Huckaby, "A Study of the Cascade Board as a Mass Transfer Device," Ph. D. Dissertation, Louisiana State University, 1960.

9. "An Industrial Guide to the Cane Sugar Industry," Public Health Service Publication Number 691 (1959), U.S. Department of Health, Education and Welfare.

10. A. J. Isacks, "Nature and Disposal of Sugar Factory Wastes in Louisiana," Water Conferences, Stream Control Commission, Baton Rouge, Louisiana, 1946, pp. 37 - 39.

11. Arthur G. Keller, "Water Usage and Conservation in the Sugar Industry," Proceedings, Second Annual Symposium on Water Conservation and Industrial Development, LSU Engineering Experiment Station Bulletin No. 38, 1953.

12. Arthur G. Keller and Joseph E. Wheeler, Jr., "Water Pollution and the Sugar Industry," The Sugar Journal, April, 1956, p. 20.

13. Arthur G. Keller and Joseph R. Wheeler, "Pollution Abatement in the Louisiana Sugar Industry," Proceedings of the Fifth Annual Water Symposium, 1956, College of Engineering and The General Detention Division of Louisiana State University.

14. Arthur G. Keller and H. K. Huckaby, "Pollution Abatement and the Sugar Industry of Louisiana," Journal Water Pollution Control Federation, July, 1960, p. 755.

15. Robert A. Lafleur, "Water Quality in Louisiana Streams Receiving Sugar Factory Wastes," *1967 Proceedings of the American Society of Sugar Cane Technologists*.

16. Ali Sajjidian, "Biological Oxidation Rate of Aquesous Sugar Solutions," M.S. Thesis, Louisiana State University, 1964.

17. "South Florida Sugar Industry, September 15 - 24 and November 11 - December 18, 1964," Florida State Board of Health, Bureau of Sanitary Engineering, Jacksonville, Florida.

18. *Standard Methods for the Examination of Water and Waste Water*, Twelfth Edition, Boyd Printing Company, 1965.

19. Joseph E. Wheeler, Jr., "An Engineering Study of the Effluent Disposal Problems of the Louisiana Raw Sugar Industry," Ph. D. Dissertation, Louisiana State University, July, 1960.

20. George E. Wilson, "Application of Jet Aeration to Sugarcane Waste Waters," *1970 Proceedings of the American Society of Sugar Cane Technologists*.

SUMMARY

ANNUAL MEETING

AMERICAN SOCIETY OF SUGARCANE TECHNOLOGISTS

February 5, 1970

The Annual Meeting of the American Society of Sugarcane Technologists was held on Thursday, February 5, 1970, at the Bellemont Motor Hotel, Baton Rouge, Louisiana.

The meeting was called to order by President J. A. Dornier, Jr. at 9:45 A.M. After a few opening remarks and announcements, he presented Mr. Ramon Billeaud, Chairman of the Manufacturing Section, who introduced the following program beginning at 10:00 A.M.:

Application of Jet Aeration to Sugarcane Waste Water	Dr. George E. Wilson Penberthy-Houdaille Industrials Inc., Prophetstown, Illinois
The Supple System - A New Alternative for Cane Handling on the Mill Yard	Glenn Timmons American Sugarcane League New Orleans, Louisiana
Removal of Starch from Sorghum Juice - B. A. Smith, Food Crops Utilization Research Lab, Weslaco, Texas	Dr. Frank Carpenter Southern Regional Research Lab, New Orleans, Louisiana

At the close of the session, Mr. Billeaud presented certificates of appreciation to each of the participants.

The meeting was recessed for lunch.

At 2:00 P.M., President Dornier convened the afternoon session. He presented Dr. James Irvine, Chairman of the Agricultural Section who introduced the following program:

Sweet Sorghum for Sugar Production	Dr. Robert Coleman Crops Research Division ARS, USDA

Some Proposed Modifications of Sugarcane Breeding Programs In Louisiana	Dr. M. T. Henderson Dept. of Agronomy L.S.U.
Water Management in Sugarcane Production	Cade Carter Soil and Water Conservation Division, USDA
Business Meeting	J. A. "Pete" Dornier, President
Banquet	Guest Speaker: Roy Theriot, Comptroller State of Louisiana

Chairman Irvine presented each participant a certificate of appreciation from the Society for their presentation.

There followed a Business Session. Items discussed, action taken, etc., are as follows:

1. A financial statement was presented by Denver T. Loupe, Secretary-Treasurer and approved as distributed.

2. President Dornier called for a moment of silent prayer for deceased Society members. Those listed were: Nicholas Bergeron, Roland Toups, and Edwin L. Dennis.

3. A report by Thomas Allen was presented on the negotiations and recommendations concerning the involvement of the Florida Sugar industry in activities of the American Society of Sugarcane Technologists. To satisfactorily bring this about, a general rewriting of the Constitution and By-Laws was required. This was done and tentatively approved by Florida.

The membership having been duly notified approved the new Constitution upon a motion by Ramon Billeaud and seconded by Horace Nelson. A copy of the revised Constitution will be officially published in the 1970 Proceedings.

4. Due to additional responsibilities with his organization and change in domicile, Mr. W. S. Chadwick had to relinguish his duties as General Chairman of the XIV Congress ISSCT. The name of F. A. Graugnard, Jr. was proposed by

Thomas Allen, seconded by Clay Terry, and unanimously approved to replace Bill as General Chairman for the ISSCT Congress in 1971.

5. Dr. James Irvine reported for the committee charged to study the feasibility of our Society publishing a "Technical Supplement" to the proceedings. A proposal was prepared, but in view of the merger with Florida and other organizational changes, it is anticipated that the intent of this committee's proposal will be accomplished.

6. Minus Granger, Chairman of the Honorary Membership Committee composed of Charles Savoie and Thomas Allen, proposed the name of Irwin L. Saveson which was approved by the membership. Motion was made by R. T. Gibbens and seconded by L. C. Bourgeois.

7. A letter from Dr. John Seip was read in which a request was made for the Society to sponsor the erection of a plaque in honor of Dr. Arthur Keller. This plaque to be prominently displayed on the newly proposed Engineering Building to be constructed on the L.S.U. Campus. It was moved by Victor Baelliet and seconded by Frank Barker that the Society provide funds for this plaque, not to exceed $1,000.00. Motion adopted.

Meeting adjourned at 4:35 P.M.

The annual Banquet convened at 6:45 P.M. Invocation was given by Clay Terry, Immediate Past President.

Following the introduction of persons seated at the head table, Minus Granger, First Vice-President presented a certificate of Honorary membership to Mr. I. L. Saveson. He introduced other Honorary members present.

Mr. F. A. Graugnard, Jr. recognized the Past Presidents who were in attendanc

The guest speaker was introduced by President Dornier. He was Mr. Roy Theriot, Comptroller, State of Louisiana who spoke on the "Heritage of South Louisianians."

Special guests were recognized.

The following officers for 1970 were presented:

Minus Granger	President
F. A. Graugnard, Jr.	First Vice-President
James Irvine	Second Vice-President
Denver T. Loupe	Secretary-Treasurer
C. H. Burleigh	Chairman, Agricultural Section
Connie Melancon	Chairman, Manufacturing Section
Charles Savoie	Chairman, At Large
J. A. Dornier, Jr.	Immediate Past President

In accepting the presidency for 1970, Mr. Granger pledged renewed efforts toward the improvement of the Society. Following the presentation of a suitably inscribed gavel to Past-President Dornier, the Banquet was adjourned.

Respectfully submitted,

Denver T. Loupe

Denver T. Loupe
Secretary-Treasurer

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SUMMARY

SUMMER MEETING

AMERICAN SOCIETY OF SUGARCANE TECHNOLOGISTS

Francis T. Nichols State College
Thibodaux, Louisiana
Thursday, June 4, 1970

The Summer Meeting of the American Society of Sugar Cane Technologists was held in Peltier Auditorium at Francis T. Nichols State College on Thursday, June 4, 1970. President Minus J. Granger called the meeting to order at 9:25 A.M. Dr. Robert Falgout welcomed the members in behalf of the college administration. Following several announcements, President Granger presented Mr. Connie Melancon, Chairman of the Manufacturing Section, for the presentation of a panel on "Sugar Industry Pollution Problems."

The moderator of the panel was Mr. James Thibaut, President and General Manager of Evan Hall Factory, McCall, Louisiana. Panel participants included Mr. Octave Gutekunst, Vice-President and Manager, St. John Factory, St. Martinville who presented a paper on "Pollution at the Factory" which was prepared by Dr. John Seip. Others were Mr. Robert LaFleur, Executive Secratary of the Louisiana Stream Control Commision who spoke on "Stream Pollution Problems" and Mr. Vernon C. Parker, Chief, Air Control Section, Louisiana State Department of Health, who presented "Air Pollution Problems."

At 11:00 A.M., President Granger presented Mr. Calvin H. Burleigh, Chairman of the Agricultural Section. He introduced Mr. P. J. de Gravelles, Jr. who moderated a panel on "Trash in Cane." Panel topics and participants included:

Trash	Octave Gutekunst St. John Factory St. Martinville, Louisiana

Trash Determination and Sampling Procedures--Future Trends	Dr. Benjamin Legendre USDA Sugarcane Field Station Houma, Louisiana
Cane Cleaning--Where and How	Harold Willet Cane Machinery and Engineering Company Thibodaux, Louisiana

Following the sectional meetings, the respective chairman presented certificates of appreciation to those who had participated on the program.

There followed a brief business session at which time the officers of the Florida Division were introduced:

President - W. J. "Bill" Miller

First Vice-President - Dr. Leo P. Hebert

Second Vice-President - Jack Martinez

Chief Manufacturing Secretary - Guillermo Alleman

Chief Agricultural Secretary - P.M. McIntyre

Chief at Large - Nelson Fairbanks

Secretary Treasurer - Charles Freeman

President Granger announced that the Louisiana Division annual meeting would be held on February 4, 1971, at the Bellemont Motor Hotel, Baton Rouge. The first joint meeting to be held during early June, at a date and place to be selected by the Joint Executive Committee. Following a few other announcements, the meeting adjourned for a social hour and lunch at the V.F.W. Building.

Respectfully Submitted,

Denver T. Loupe

Denver T. Loupe
Secretary-Treasurer

DTL:rw

CONSTITUTION OF THE

AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

(As amended and restated February 5, 1970)

ARTICLE I

Name, Object and Domicile

Section 1. The name of this Society shall be the American Society of Sugar Cane Technologists.

Section 2. The object of this Society shall be the general study of the sugar industry in all its various branches and the dissemination of information to the members of the organization through meetings and publications.

Section 3. The domicile of the Society shall be at the Louisiana State University and Agricultural and Mechanical College, Baton Rouge, Louisiana, USA.

ARTICLE II

Divisions

The Society shall be composed of two divisions, the Louisiana Division and the Florida Division. Each division shall have its separate membership roster and separate officers and committees. Voting rights of active members shall be restricted to their respective divisions, except at the general annual and special meetings of the entire Society, hereinafter provided for, at which general meetings active members of both divisions shall have the right to vote. Officers and committeemen shall be members of and serve the respective divisions from which elected or selected, except the General Secretary-Treasurer who shall serve the entire Society.

ARTICLE III

Membership and Dues

Section 1. There shall be five classes of members: Active, Associate, Supporting, Honorary and Off-shore or Foreign.

Section 2. Active members shall be individuals residing in the continental United States actually engaged in the production of sugar cane or the manufacture of cane sugar, or research or education pertaining to the industry, including employees of any corporation, firm or other organization which is so engaged.

Section 3. Associate members shall be individuals not actively engaged in the production of sugar cane or the manufacture of cane sugar or research pertaining to the industry, but who may be interested in the objects of the Society.

Section 4. Supporting members shall be persons engaged in the manufacturing, production or distribution of equipment or supplies used in conjunction with production of sugar cane or cane sugar, or any corporation, firm or other organization engaged in the production of sugarcane or the manufacture of cane sugar, who may be interested in the objects of the Society.

Section 5. Off-shore or Foreign members shall be individuals not residing in the Continental United States sho may be interested in the objects of the Society.

Section 6. Honorary membership shall be conferred on any individual who has distinquished himself in the sugar industry, and elected by a majority vote of the Joint Executive Committee. Honorary members shall be exempt from dues and entitled to all the privileges of active membership.

Section 7. Applicants for membership shall make written application to the Secretary-Treasurer of the respective divisions, endorsed by two active members of the division, and such applications shall be acted upon by the division membership committee.

Section 8. Annual dues shall be as follows:

Suppporting Membership	$30.00
Associate Membership	$15.00
Off-shore or Foreign Membership	$10.00
Active Membership	$ 5.00
Honorary Membership	NONE

Dues for each calendar year shall be paid not later than December 1 of such year. New members shall pay the full amount of dues, irrespective of when they join.

Section 9. Dues shall be collected by each of the Division Secretary-Treasurers from the members in their respective divisions. Unless and until changed by action of the Joint Executive Committee, 30% of all dues collected shall be transmitted to the office of the General Secretary-Treasurer.

Section 10. Members in arrears for dues for more than a year will be dropped from membership after thirty days notice to this effect from the Secretary-Treasurer. Members thus dropped may be reinstated only after payment of back dues and assessments.

Section 11. Only active members of the Society shall have the privilege of voting, holding office and initiating discussion from the floor at division and general meetings.

ARTICLE IV

General Secretary-Treasurer and Joint Executive Committee

Section 1. The General Secretary-Treasurer shall serve as Chief Administrative Officer of the Society and shall coordinate the activities of the divisions and the sections. He will serve as ex-officio Chairman of the Joint Executive Committee and as General Chairman of the General Society Meetings, and shall have such other duties as may be delegated to him by the Joint Executive Committee. His office shall be at the domicile of the Society.

Section 2. The Joint Executive Committee shall be composed of the members of the two division Executive Committees, and is vested with full authority to conduct the business and affairs of the Society.

ARTICLE V

Division Officers and Executive Committee

Section 1. The officers of each division of the Society shall be: A President, a First Vice-President, a Second Vice-President, a Secretary-Treasurer, and an Executive Committee composed of these officers and three other members, one from each Section of the Division (as described in Section 3 of Article VII) and one elected at large.

The Ex-President shall serve as an Ex-Officio member of the Division Executive Committee for one year following his term of office.

Section 2. These officers, except Secretary-Treasurer, shall be nominated by a nominating committee and voted upon before the annual division meeting. Notices of such nominations shall be mailed to each member at least one month before such meeting. Ballots not received before noon of the Saturday preceeding the first day of the meeting will not be counted.

Section 3. The Secretary-Treasurer shall be appointed by and serve at the pleasure of the Division Executive Committee.

Section 4. The duties of these officers shall be such as usually pertain to such officers in similar societies.

Section 5. Each section as described in Article VII shall be represented in the offices of the President and Vice-President.

Section 6. The officers of the Division shall hold office for one year only, or until their successors shall be elected.

Section 7. No one may be elected President of the Division for two consecutive years.

Section 8. The President shall be elected each year alternately from the two sections hereinafter provided for. The President for each Division shall be nominated and elected from a different Section. The President from the Louisiana Division for the year beginning February, 1970, shall be nominated and elected from the Agricultural Section. The President from the Florida Division for the year beginning February, 1970, shall be nominated and elected from the Manufacturing Section.

Section 9. Vacancies occurring between meetings shall be filled by the Division Executive Committee.

Section 10. The terms "year" and "consecutive year" as used in Articles V and VI shall be considered to be comprised of the elasped time between one annual division meeting of the Society and the following annual division meeting of the Society.

ARTICLE VI

Division Committees

Section 1. The President of each division shall appoint a committee of three to serve as a Membership Committee. It will be the duty of this committee to pass upon applications for membership in the division and report to the Secretary-Treasurer.

Section 2. The President of each division shall appoint each year a committee of three to serve as a Nominating Committee. It will be the duty of the Secretary of the Division to notify all active members of the Division as to the personnel of this committee. It will be the duty of this committee to receive nominations and to prepare a list of nominees and mail this to each member of the Division at least a month before the annual Division meeting.

ARTICLE VII

Sections

Section 1. There shall be two sections of each Division, to be designated as:

1. Manufacturing
2. Agricultural

Section 2. Each active member shall designate whether he desires to be enrolled in the Manufacturing Section or the Agricultural Section.

Section 3. There shall be a Chairman for Each Section of each Division who will be the member from that Section elected to the Executive Committee. It will be the duty of the Chairman of a section to arrange the program for the annual Division meeting.

Section 4. The Executive Committee of each Division is empowered to elect one of their own number or to appoint another person to handle the details of printing, proof reading, etc., in connection with these programs and to authorize the Treasurer to make whatever payments may be necessary for same.

ARTICLE VIII

Meetings

Section 1. The annual General Meeting of the members of the Society shall be held in June each year on a date and at a place to be determined, from time to time, by the Joint Executive Committee. At all meetings of the members of the Society 5% of the active members shall constitute a quorum. The program for the annual meeting of the Society shall be arranged by the General Secretary-Treasurer in collaboration with the Joint Executive Committee.

Section 2. The annual meeting of the Louisiana Division shall be held in February of each year, at such time as the Executive Committee of that Division shall decide. The annual meeting of the Florida Division shall be held in of each year, at such time as the Executive Committee of that Division shall decide. Special meetings of a Division may be called by the Executive Committee of such Division.

Section 3. Special meetings of a Section for the discussion of matters of particular interest to that Section may be called by the President upon request from the respective Chairman of a Section.

Section 4. At Division meetings, ten percent of the active division members and the President or a Vice-President shall constitute a quorum.

ARTICLE IX

Management

Section 1. The conduct and management of the affairs of the Society and of the Divisions including the Direction of work of its special committees, shall be in the hands of the Joint Executive Committee and Division Executive Committees, respectively.

Section 2. The Joint Executive Committee shall represent this Society in conferences with the American Sugar Cane League, The Florida Sugar Cane League, or any other association, and may make any rules or conduct any business not in conflict with this Constitution.

Section 3. Four members of the Division Executive Committee shall constitute a quorum. The President, or in his absence one of the Vice-Presidents, shall be Chairman of this committee.

Section 4. Two members of each Division Executive Committee shall constitute a quorum of all members of the Joint Executive Committee, and each Division shall be entitled to one vote, regardless of the number of committee members present.

ARTICLE X

Amendments

Section 1. Amendments to this Constitution may be made only at the annual meeting of the Society or at a special meeting of the Society. Written notices of such proposed amendments, accompanied by the signature of at least twenty (20) active members must be given to the General Secretary-Treasurer at least thirty (30) days before the date of the meeting, and he must notify each member of the proposed amendment before the date of the meeting.

Section 2. Amendments shall be adopted by a two-thirds majority of those voting.

Sugarcane Varieties in Florida: Past, Present, and Future

Norman I. James[1]

Numerous varieties of sugarcane have been grown in Florida during the long history of the crop. This sugar-producing plant probably was introduced by the Spaniards soon after St. Augustine was founded in 1565. Bourne (2,3) and Vaughn (1) have discussed the history of sugar culture in Florida and pointed out that lack of suitable varieties was one of the major reasons for failure of several commercial enterprises.

Several attempts were made to produce sugar commercially between 1767 and 1930. Ruins of old mills suggest that sugar production was tried as early as 1700 near Port Orange, New Smyrna, and De Leon Springs (2). Sugar was produced on a commercial scale at the New Smyrna Colony between 1767 and 1776. This colony disbanded in 1777 and the next sugar enterprise of consequence was in Manatee County between 1850 and the early 1860's. More than two million pounds of sugar was produced annually by 1860, but the Civil War and a disastrous fire destroyed the operation. Beginning in 1886, the St. Cloud Sugar Company grew sugarcane commercially in the Kissimmee River Valley and attempted to grow the crop on muck soil on the southwest shore of Lake Okeechobee. This enterprise was successful for a few years but closed in 1896. Between 1900 and 1920 the

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[1] Research Agronomist, Tobacco and Sugar Crops Research Branch, Crops Research Division, U. S. Department of Agriculture, Agricultural Research Service, Canal Point, Florida.

Moore Haven Sugar Company planted cane at Moore Haven, and in the Disston Island and Canal Point districts. In 1920, the Florida Sugar and Food Products Company tried to grow sugarcane on muck lands near Canal Point. This venture was not profitable and the properties were acquired later by the Southern Sugar Company. This Company failed also, but large tracts of land were acquired along the southern and eastern shores of Lake Okeechobee, and a modern sugar mill was purchased from the Pennsylvania Sugar Company of Hialeah, Florida and moved to Clewiston. The first successful long-term sugar enterprise in Florida was initiated in 1931 [1/] when the United States Sugar Corporation took over the Southern Sugar Company. Another successful sugar operation was established at Fellsmere (about 70 miles north of Canal Point) in the early 1930's, and sugar was produced in that area until 1965. A commerical sugar concern was developed at Okeelanta during World War II. This company failed after the war, but Okeelanta Sugar Refinery, Inc., bought the property and conducted a successful operation. By 1953, the sugarcane acreage in Florida had increased to 43,000.

During the early 1960's, the sugarcane acreage was increased more than four-fold to compensate for the sugar that was no longer imported from Cuba. There were about 220,000 acres of sugarcane harvested and processed in 11 mills during the 1964-65 season.

[1/] Grateful acknowledgment is made to Dr. B. A. Bourne, Advisor, United States Sugar Corporation, Clewiston, Florida, for providing data on development of the Florida sugar industry and and on development of sugarcane breeding.

Original Sugarcane Varieties

Only "noble" sugarcane varieties were grown throughout most of the world before 1915. These varieties belong to the species *Saccharum officinarum* and they are characterized by low vigor, late maturity, and susceptibility to diseases. According to Grassl (7), these varieties originated from natural hybridization within a related species in New Guinea. The native population selected desirable individuals and maintained them in gardens for food. Early migrating peoples acquired representatives of these canes and spread them throughout the Polynesian world. As the European people began to explore and colonize the New World, this sugar-producing plant was established in tropical and subtropical areas. Columbus brought sugarcane to Santo Domingo on his second voyage in 1493 and, as previously mentioned, the plant probably was brought to Florida before 1600. The exact number of varieties that was established in various areas of the world is not known, and later identification of these early varieties was difficult because they acquired local names in the different areas where they were grown. Some of these synonyms were identified by studying varieties that are maintained in the World Reference Collection at Canal Point. However, new techniques such as "finger-printing," which is the study of isoenzyme patterns, must be utilized to further clarify this confusing situation (9). Some of the more important noble varieties were Crystalina, Creole, Otaheite, Louisiana Purple, Louisiana Striped, D. 74, and D. 95. Some researchers consider Creole to be a natural hybrid between a noble cane and an unknown related species. The date of introduction of particular varieties into Florida has not been established; but

Matherne (13) has given dates for introduction into Louisiana (Table 1). It is likely that introduction into Florida followed a somewhat similar pattern.

Sugarcane Breeding From 1900-1925

Conscious efforts to improve the sugarcane plant were not made until the late 1800's. Prior to that time, commercial varieties were selected from the noble canes that originated naturally over a period of several centuries. The first widely accepted evidence that sugarcane produced true seed was not obtained until 1887-88 in Java and Barbados (4). This information, along with the development of plant breeding as a science, made possible improvement programs through hybridization and selection. By 1911, experiment stations in Java and Barbados had produced several commerical varieties by intercrossing noble canes. Crosses between nobles and two related species, Saccharum barberi and Saccharum spontaneum weremade in Java during this period. Several of these hybrid seedlings were later grown commercially in various places in the world, including Florida. By 1912, crosses had been made between nobles and an Indian form of Saccharum spontaneum at an experiment station which was established at Coimbatore, India.

The U. S. Department of Agriculture established an experiment station on Collins Key (now Miami Beach) in 1918, but moved the operation to Canal Point in 1920. The major goal of this station was to develop varieties to replace the noble varieties D. 74 and Louisiana Purple, which were failing in Louisiana because of susceptibility to mosaic, root rot, and red rot (4). A collection of varieties from throughout the world was assembled at Canal Point, and this set the stage for the development of varieties adapted to Florida as well as to Louisiana.

By this time, research workers in Java had crossed noble canes and Kassoer (a natural noble x S. spontaneum hybrid) and were well on the way to developing such world famous varieties as P.O.J. 2714, P.O.J. 2725, and P.O.J. 2878.

Two approaches were used in these early cane breeding programs. One approach was to intercross noble canes which yielded several commercial varieties as P.O.J. 100, E.K. 2, and E.K. 28. These noble hybrids were important not only as commercial varieties, but as parents in subsequent breeding work. The second approach was to cross noble varieties and a wild form. Wild forms were chosen because of disease resistance or hardiness under severe subtropical conditions (in Java, resistance to sereh disease was of major concern). Several of the F_1 generation seedlings were grown commercially in different places in the world (including Florida). Among these were Co. 205, P.O.J. 213, P.O.J. 234, P.O.J. 36, and P.O.J. 36M. However, further backcrosses to other nobles resulted in much improved varieties such as P.O.J. 2714, P.O.J. 2725, P.O.J. 2878, and Co. 290. This approach became widely known as a "nobilization" program because the progeny were made more like the noble parent in fiber content, stalk diameter, and juice quality, while retaining the disease resistance and vigor of the wild parent. Brandes and Sartoris (4) attributed the major part of the 300 percent increase in sugar production per unit area in Java between 1885 and 1925 to the nobilization program.

Sugarcane Breeding 1925 to 1970

Prior to 1925, sugar production on the Everglades muck was particularly disappointing because of improper fertilization, poor drainage, and varieties that were not adapted to high nitrogen organic soils. Sugarcane breeding for Florida conditions was sponsored by the Southern Sugar Company in 1929 and this effort was continued by the United States Sugar Corporation after it acquired these properties in 1931.

The varieties grown by the United States Sugar Corporation during the period from 1932 to 1950 are shown in Figure 1 (2). Efforts to develop varieties adapted specifically to Everglades muck were beginning to pay dividends by 1938. F. 31-436 and F. 31-962 rapidly replaced P.O.J. 2725 and they were the dominant varieties until Cl. 41-223 replaced them in the 1950's.

The varieties grown in the Fellsmere area between 1945 and 1954 are shown in Figure 2 (2). The Everglades Experiment Station initiated cane-breeding activities during the 1930's and some of their varieties were being grown by 1938. Co. 290 was the dominant variety at Fellsmere until 1949 when it was replaced by F. 36-819 and C.P. 34-79. F. 36-819 was one of the more popular varieties produced by the Everglades Experiment Station and C.P. 34-79 was the first Canal Point variety to attain commercial importance in Florida.

The parents of these varieties were hybrids from India, Java, and Canal Point. The Canal Point hybrids were obtained by intercrossing or by further "nobilizing" Javanese and Indian hybrids. Selected progeny of these early crosses also became important parents of later Florida varieties.

Expansion of the Florida sugar industry from 49,000 to 229,000 acres in the early 1960's focused additional attention on variety development. Most of the new sugarcane acreage was in colder areas away from the shores of Lake Okeechobee. Varieties adapted to these areas were needed. During the early years some seedlings were grown at the Canal Point Station and selected for adaptability to Florida conditions; but it was not until the early 1960's that the U. S. Department of Agriculture, the Everglades Experiment Station, the Okeelanta Sugar Refinery, Inc., and the Sugar Cane Growers Cooperative of Florida established an agreement to develop varieties adapted to the newer and colder lands away from Lake Okeechobee. Under this agreement, 359,000 seedlings were grown between 1957 and 1964 (14). During the next two years, the U. S. Department of Agriculture, the Everglades Experiment Station, and the sugar industry (represented by the Florida Sugar Cane League, Inc.) developed a new and expanded cooperative program. Under this program crosses are made at Canal Point and seedlings are grown at two locations. The U. S. Department of Agriculture grows approximately 100,000 seedlings per year at the Canal Point Station and the Everglades Experiment Station growers about 50,000 seedlings per year near Belle Glade. Eight test fields are located throughout the sugar-growing area where advanced selections are evaluated for tons of cane per acre, sucrose content, stubbling ability, general growth characteristics, and reaction to disease and insects. Six of these test fields are under the direction of the U. S. Department of Agriculture personnel and two are under the direction of Everglades Experiment Station personnel. Sugar companies and individual growers provide land, labor, and equipment for conducting these tests. As a result of this increased interest in variety development, the facilities and staff at the Canal Point Station were expanded.

The changes in Florida varieties between 1930 and 1970 are shown in Figure 3 (8). Cl. 41-223 occupied 87 percent of the sugarcane acreage in 1962. This outstanding variety still occupies 66.4 percent of the total acreage in the State, but it has declined slowly and steadily during the past eight years. Several varieties have been increased briefly only to decline and be replaced by other varieties. Among the varieties to achieve second place in total acreage were C.P. 50-28, Cl. 47-83, and C.P. 57-603. It is likely that C.P. 63-588 will be in second place by 1971. This succession of second-place varieties can be interpreted to mean that even though Cl. 41-223 is not performing well, particularly on cold land, a satisfactory replacement has not yet been developed. At the present time, there are more than 20 new Cl. and C.P. varieties in commercial production, and it may be that one or more of these new varieties will replace Cl. 41-223.

Sugarcane Breeding in the Future

For the next 10 years or so, new varieties for the Florida sugar industry probably will be developed by using the same methods that have been successful for the past 35 years. Our program at Canal Point will be modified as we learn more about the heritability of important characters, combining ability of different parents, and the response of characters to different methods of selection. We plan to continue our research on photoperiod control of flowering which has already permitted crossing several varieties that do not normally flower, or do not flower at the same time.

We are developing new breeding lines from better wild parents than those which the Javanese and Indians started with in the early 1900's (5). Expeditions to New Guinea by Brandes (4) in 1928, and by Warner and Grassl (17) in 1957, along with other sources, have provided an abundance of basic germplasm from which to select superior wild clones. The World Reference Collection which is maintained by the U. S. Department of Agriculture at Canal Point, Florida and Beltsville, Maryland is again providing the basic material for Florida varieties, as it did in the 1920's. Commercial varieties from these new lines will probably be grown within 10 to 20 years.

There are new techniques that are being applied, or will be applied, in sugarcane breeding programs. Irradiation of seed-pieces of a heavy-flowering variety in Barbados resulted in a non-flowering sub-clone that is being tested for commercial use (16). Tissue culture in conjunction with colchicine treatment was used successfully in Hawaii to obtain sugarcane plants with a wide range in chromosome numbers (10). Mitochrondrial complementation is being used in other crops to determine which parents will produce vigorous seedlings (15). This is done in a test tube in the laboratory, and thereby restricts the expensive steps of crossing and field testing of offspring to only those parents that show promise of producing superior seedlings.

Chromosome engineering may some day permit failing commercial varieties to be repaired and updated in the laboratory by inserting or deleting particular chromosomes. However, standard breeding methods applied to available breeding lines will provide varieties for the Florida sugar industry in the near future.

Literature Review

1. Anonomyous 1964 Sugarcane in Florida. Bankers Farm Bulletin. Federal Reserve Bank of Atlanta 16:1-2.
2. Bourne, B. A. 1956. Sugarcane cultivation throughout the world. Florida Chapter Advance reprint for private circulation, March 1956. The Chronica Botanica Co., Waltham, Mass. U.S.A. p. 1-22, illus.
3. Bourne, B. A. 1961. History of sugarcane production and areas suitable for expanding its culture in south Florida. Soil and Crop Sci. Soc. of Fla. 21:82-89.
4. Brandes, E. W. and G. B. Sartoris. 1936. Sugarcane: its origin and improvement. Yearbook of Agriculture. U. S. Gov't. Printing Office, Washington, D. C. pp. 561-611.
5. Dunckelman, P. H and R. D. Breaux. 1968. Evaluation of germ plasm in the USDA sugarcane program at Houma, Louisiana. Int. Soc. Sugar Cane Technol. Proc. 13th Cong. pp. 888-892.
6. Falgout, R. N., N. I. James, and E. R. Rice. 1968. Development of new sugarcane varieties for Florida. Sugar Bul. 46:7, 10, 11, 12.
7. Grassl, C. O. 1968. Saccharum names and their interpretation. Int. Soc. Sugar Cane Technol. Proc. 13th Cong. pp. 868-875.
8. Hebert, L. P. The 1970 sugarcane variety census for Florida. In Press.
9. Heinz, D. J. 1969. Isoenzyme prints for variety identification. I.S.S.C.T. Sugar Cane Breeders' Newsletter 24:8.
10. Heinz, D. J. and G. W. P. Mec. 1970. Use of cell suspension and callus techniques in sugarcane as a breeders' tool.

Agronomy Abstracts. American Journal of Agronomy, Madison, Wis. p. 11.

11. James, N. I. and E. R. Rice. 1966. Florida sugarcane breeding programme. Proc. British West Indies Sugar Technol. 1:34-37.

12. Jernigan, W. P. 1945. Varietal trend in the Florida Everglades. Sugar Bul. 23:118.

13. Matherne, R. J. 1968. A history of major Louisiana sugarcane varieties. Int. Soc. Sugar Cane Technol. 13th Cong. Proc. pp. 1056-1061.

14. Rice, E. R., and P. H. Dunckelman. 1964. Florida sugarcane seedling program from crosses and seed production at Canal Point 1957-64. Sugar Bull. 42:254-262.

15. Sarkissian, I. V. and H. K. Srivastava. 1967. Mitochondrial polymorphism in maize. II. Further evidence of correlation of mitochondrial complimentation and heterosis. Genetics 57:843-850.

16. Walker. D. I. T. and N. S. Sisodia. 1969. Induction of a non-flowering mutant in sugarcane (Saccharum sp.). Crop Sci. 9:551-552.

17. Warner, J. N. and C. O. Grassl. 1959. The 1957 New Guinea Expedition for collection of sugarcane. Int. Soc. Sugar Cane Technol. Proc. 10th Cong. pp. 792-793.

Table 1. Date of introduction or release of noble varieties in Louisiana

Variety	Date
Creole *	1751
Otaheite	1790
Louisiana Purple	1821-22
Louisiana Striped	1821-22
D. 74	1898
D. 95	1898

* This clone may be a natural hybrid between a noble and a related species.

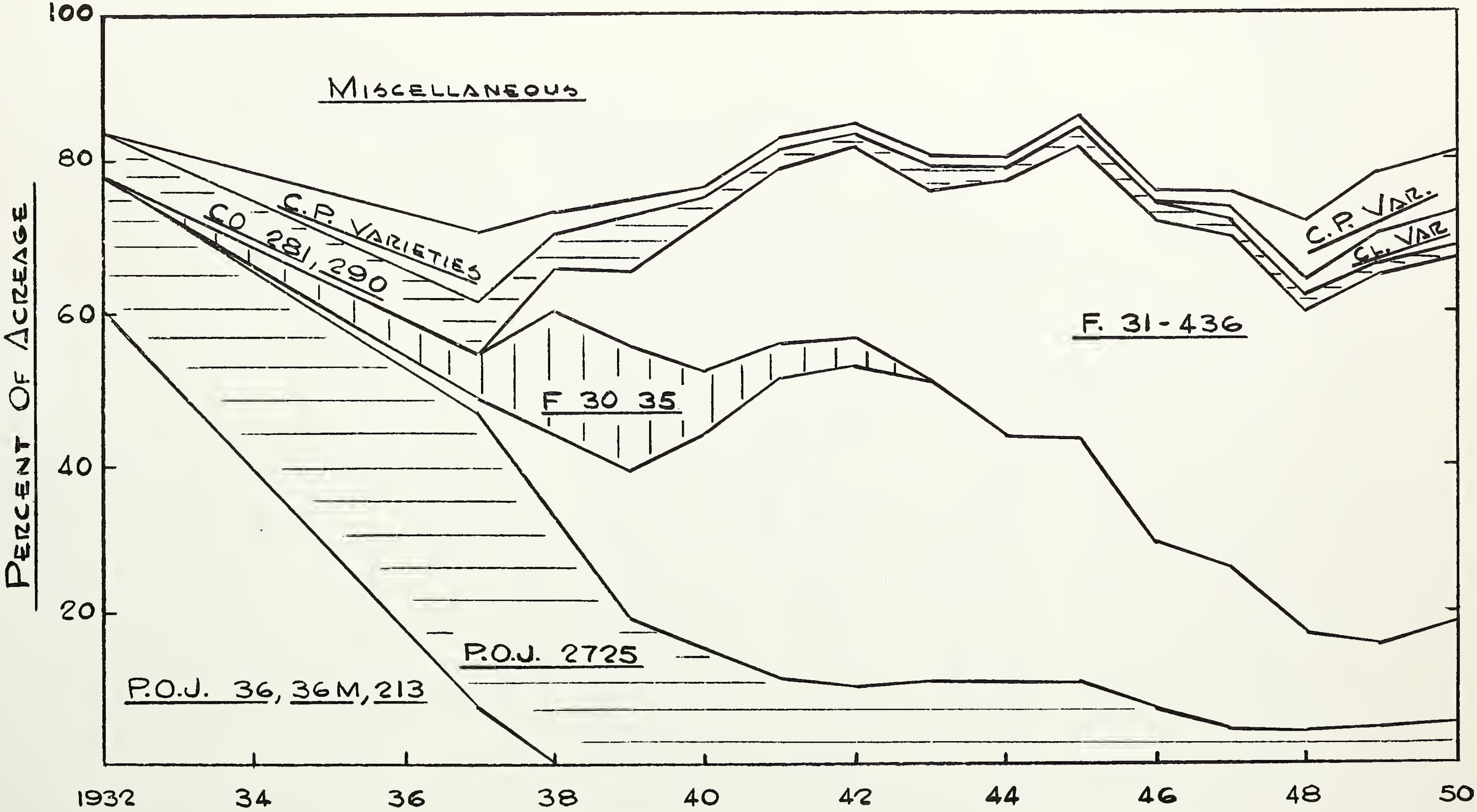

Figure 1 - Trend of variety census, U. S. Sugar Corporation, 1932-1950.

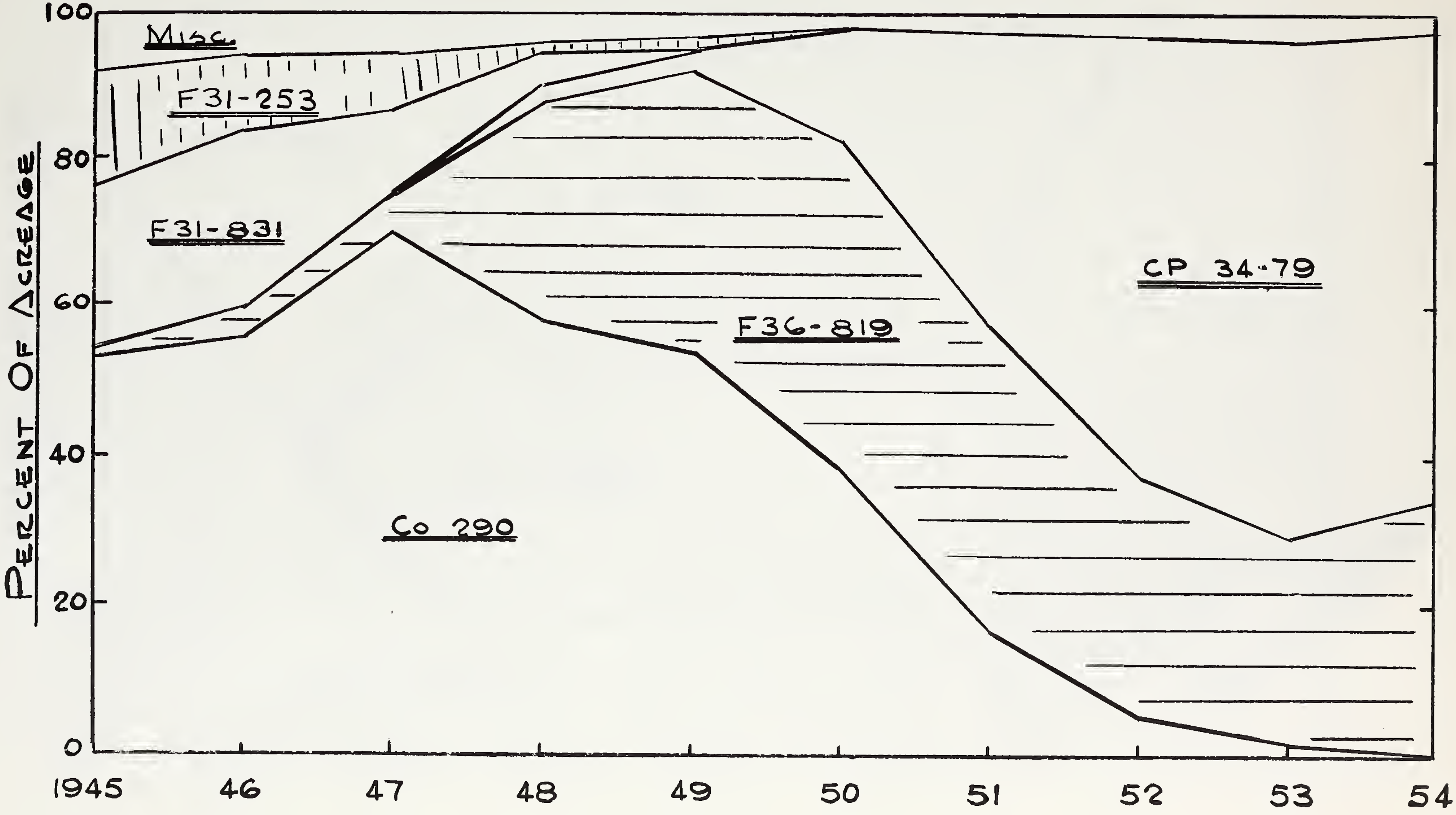

Figure 2 - Trend of variety census. Fellsmere Sugar Producers' Association, 1945-1954.

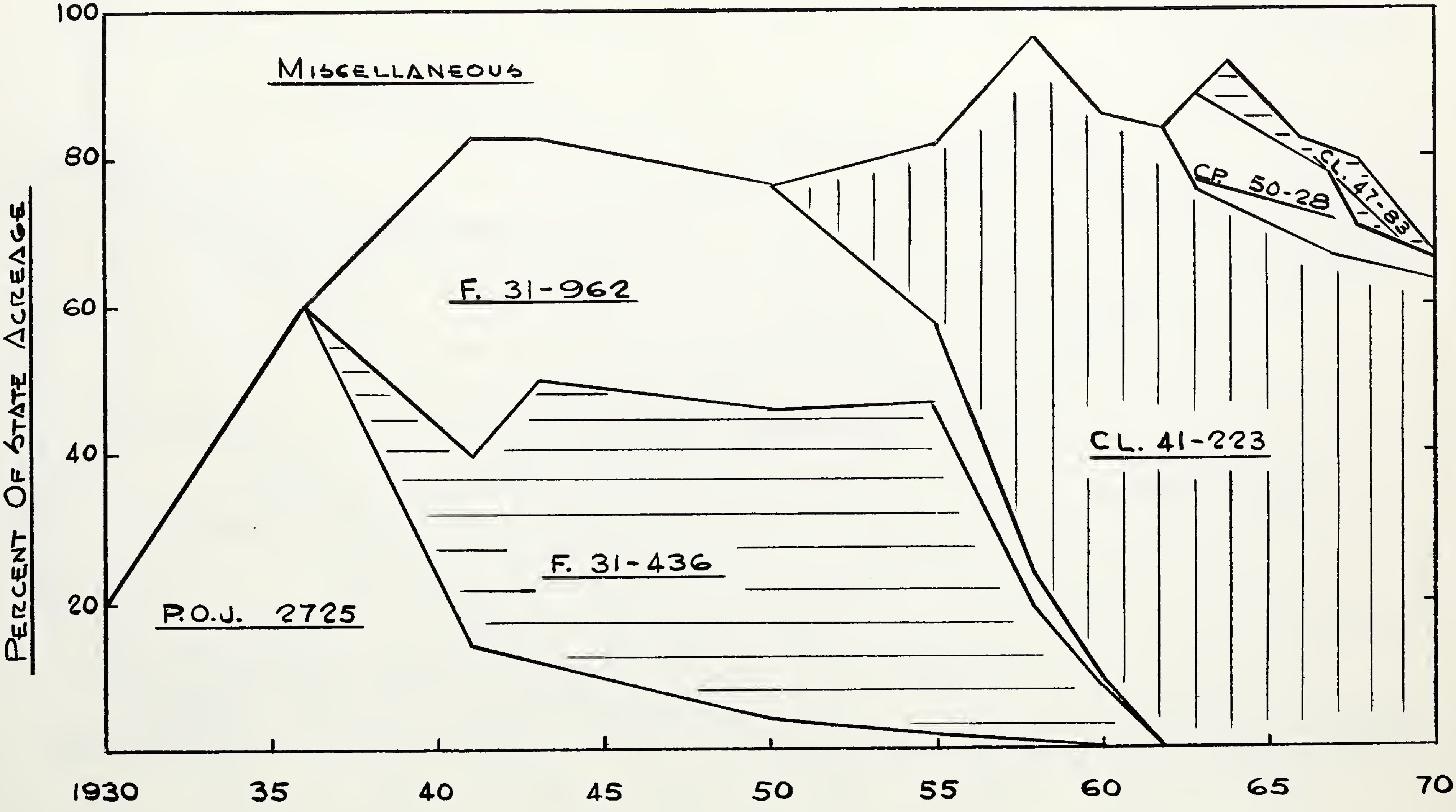

Figure 3 - Relative changes in sugarcane varieties based on percentage of the acreage planted in Florida, 1930-1970.

The Performance of Canal Point Varieties in the Florida Sugar Industry

E. R. Rice[1]

Sugarcane varieties adapted to various growing conditions continue to be of great importance to the sugar industry. For this reason, the Sugarcane Field Station at Canal Point was established in 1920, and for the past 50 years has been actively engaged in the production of true seed for the sugarcane areas of Louisiana, Mississippi, Georgia, and Florida.

Agronomic variety experiments for Florida were quite limited during the early years but were extended as the industry continued to expand. Most of the early variety testing work was done on the sand and peat soils at Fellsmere, where sugarcane was grown from 1933 to 1965. Extensive experiments have also been maintained on properties of the South Puerto Rico Sugar Company and the United States Sugar Corporation.

With the vast expansion of the Florida sugarcane industry in the early 1960's, it was apparent that new varieties adapted to the colder areas away from Lake Okeechobee were needed. In 1964, three new test field locations were established, in addition to those already located at Okeelanta and Fellsmere. At the present time agronomists from the Canal Point Station are testing new varieties at six locations throughout the sugarcane area. Seedcane for a sand land experiment will be planted this fall. This work is conducted in cooperation with the Everglades Experiment Station and the Florida Sugar Cane League, Inc.

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[1] Research Agronomist, Tobacco and Sugar Crops Research Branch, Crops Research Division, U. S. Department of Agriculture, Agricultural Research Service, Canal Point, Florida.

Eight varieties developed through this program are presently grown on a commercial basis. This report is a discussion of the performance of these varieties.

The 1969-70 harvest season was characterized by several severe freezes and an abundance of unseasonal rainfall. The commercial data in tables 1-8 was obtained from fields harvested under those extreme conditions.

Recently Released Varieties

C.P. 50-28 was released in 1957 for the peat and sandy soils of the Fellsmere area. C.P. 50-28 is a relatively early-maturing, medium-barrel, early-flowering variety. C.P. 50-28 was well adapted to the Fellsmere area and occupied a large percentage of the acreage in that area prior to the closing of the factory in 1965. During the expansion in the early 60's, C.P.50-28 was established in the sandy soils near Moore Haven and in several cold-peat locations throughout the sugarcane growing area. By 1964 C.P. 50-28 was growing on 12 percent of the Florida acreage. In recent years, C.P.50-28 occupied a smaller proprtion of the acreage and is presently being replaced with newer varieties. The main objections to C.P. 50-28 are its high-fiber content, early-flowering, and small barrel size. Some growers continued to grow C.P. 50-28 because of its outstanding stubbling ability. Data from commercial plantings show that C.P. 50-28 will produce acceptable yields in the coldest areas of the sugar industry (Table 1).

C.P. 56-59, an early-maturing, medium-barrel, non-flowering variety, was released to the Florida industry in 1967. Its fiber content is less than that of C.P. 50-28 but greater than that of Cl. 41-223. The acreage of C.P. 56-59 is increasing and the variety is performing well on a commercial basis at several plantations as shown in Table 2.

C.P. 56-63, a high-sucrose, low-fiber, early-maturing variety, was released for commercial production in 1968. In experimental variety trials this variety has not been outstanding in tons of cane per acre but it is seldom surpassed in sugar per ton of cane. This concurs with the mill data from a limited number of harvests on several plantations (Table 3).

C.P. 57-603, a large-barrel, high-tonnage, non-flowering variety, was released in 1967. The variety matures late in the harvest season and is recommended only for the warm-land near Lake Okeechobee. C.P. 57-603 is presently grown on 3.5 percent of the acreage in Florida and ranks second in percentage of the sugarcane acreage. This variety has produced outstanding yields of cane and sugar per acre when harvested late in the season (Table 4). Several instances of poor stands were reported where fields of plant cane were flooded before the seed pieces had germinated. C.P. 57-603 is also susceptible to the fungus Helminthosporium sacchari, causing eye spot of sugarcane; thus the variety is not recommended for planting in low, poorly drained areas where the humidity is high.

C.P. 57-614, released in 1968, is high in fiber content, matures early in the season, and is high in sucrose content. This variety has produced good plant and stubble crops in the colder locations, but many processors object to the high fiber content (Table 5).

C.P. 59-73, an early-maturing, high-fiber cane, was released to the industry in 1967. Like C.P. 50-28, it is outstanding in stubbling ability and has produced acceptable cane yields. (Table 6). The small barrel size and high fiber content brought the disapproval of some growers and processors.

The most recently released variety, C.P. 62-374, (released in 1969) has a large barrel and is low in fiber. This variety germinates and grows more rapidly than any other released variety, thus aiding in the control of weeds and grasses. C.P. 62-374 is not recommended for November harvest. Since it was released only recently, commercial harvests are confined to three plant-cane crops; yields have been acceptable so far (Table 7).

C. P. 63-588, an early-maturing, low-fiber, high-tonnage variety, was released in 1968. The variety shades the row well and has stubbled well after being frozen back in the winter. High-sucrose yields in plant cane have been obtained at three locations as shown in Table 8. C.P. 63-588 ranks third in the State in percentage of sugarcane acreage.

Table 1. Performance of C.P. 50-28 during the 1968 and 1969 season.

Location	Crop	Date of harvest	Normal Juice			TCA
			Brix	Sucrose	Purity	
Saunders	Pl. cane	12/8/69	16.04	12.71	79.24	42.10
Saunders	Pl. cane	12/9/69	15.65	12.21	78.02	40.40
Saunders	1st St.	12/16/69	16.31	12.84	78.72	38.42
Saunders	1st St.	12/17/69	15.98	12.96	81.10	41.70
Boynton	2nd St.	12/5/69	15.66	12.40	79.18	41.98
Simonson	6th St.	12/22/68	16.95	13.66	80.59	47.00

Table 2. Performance of C.P. 56-59 during the 1969 season.

Location	Crop	Date of harvest	Normal Juice			TCA
			Brix	Sucrose	Purity	
Hatton	Pl. cane	1/22/70	15.96	13.42	84.09	45.72
Boynton	Pl. cane	2/10/70	15.59	12.42	79.67	52.17
Roth	Pl. cane	1/13/70	16.56	13.79	83.27	47.70
Okeelanta	Pl. cane	1/1/70	17.95	16.24	90.47	50.43
Okeelanta	Pl. cane	3/3/70	17.65	15.86	89.86	43.70
Okeelanta	1st St.	2/12/70	17.69	15.93	90.05	40.39

Table 3. Performance of C.P. 56-63 during the 1969 season.

Location	Crop	Date of harvest	Normal Juice Brix	Normal Juice Sucrose	Normal Juice Purity	TCA
Hatton	Pl. cane	11/23/69	17.29	14.05	81.26	35.13
Okeelanta	Pl. cane	12/30/69	18.61	16.23	87.21	35.23
Beardsley	1st St.	11/16/69	19.04	15.76	82.77	43.70
Beardsley	1st St.	12/21/69	18.08	14.78	81.75	43.00

Table 4. Performance of C.P. 57-603 during the 1969-1970 seasons

Location	Crop	Date of harvest	Normal Juice Brix	Normal Juice Sucrose	Normal Juice Purity	TCA
Boynton	Pl. cane	2/23/70	15.18	11.87	78.19	68.81
Repper	Pl. cane	3/7/70	14.96	11.50	76.87	72.27
Boe	1st St.	3/16/70	15.90	12.70	79.87	65.68
Kautz	Pl. cane	2/22/69	17.23	14.16	82.18	101.36
Kautz	1st St.	2/4/70	15.08	11.40	75.60	70.43

Table 5. Performance of C.P. 57-614 during the 1969 season.

Location	Crop	Date of harvest	Normal Juice Brix	Normal Juice Sucrose	Normal Juice Purity	TCA
Boynton	Pl. cane	12/10/69	15.82	12.54	79.27	59.79
Okeelanta	Pl. cane	1/11/70	18.10	16.23	89.67	39.85
Okeelanta	Pl. cane	1/14/70	17.94	16.08	89.63	38.33

Table 6. Performance of C.P. 69-73 during the 1969 season.

Location	Crop	Date of harvest	Normal Juice Brix	Normal Juice Sucrose	Normal Juice Purity	TCA
Hatton	Pl. cane	11/23/69	15.97	12.47	78.08	35.60
Boynton	Pl. cane	12/11/69	15.54	12.22	78.64	46.80
Okeelanta	1st St.	11/22/69	17.85	15.88	88.96	33.63
Okeelanta	1st St.	11/23/69	17.78	16.01	90.04	31.96

Table 7. Performance of C.P. 62-374 during the 1969 season.

Location	Crop	Date of harvest	Normal Juice Brix	Normal Juice Sucrose	Normal Juice Purity	TCA
Okeelanta	Pl. cane	12/26/69	16.78	14.18	84.50	40.39
Hatton	Pl. cane	12/28/69	14.73	11.43	77.60	48.08
Beardsley	Pl. cane	12/30/69	18.16	15.05	82.87	46.10

Table 8. Performance of C.P. 63-588 during the 1969 season.

Location	Crop	Date of harvest	Normal Juice Brix	Normal Juice Sucrose	Normal Juice Purity	TCA
Beardsley	Pl. cane	1/1/70	17.08	13.74	80.44	57.00
Hatton	Pl. cane	1/22/70	16.14	13.33	82.59	42.36
Okeelanta	Pl. cane	1/20/70	18.52	17.04	92.01	43.71
Okeelanta	Pl. cane	3/1/70	18.02	16.89	93.73	38.76

WEEDS AND WEED CONTROLIN FLORIDA SUGARCANE

J.R. Orsenigo [1]

WEEDS

Weeds are an obvious problem. They may influence crop rpoduction in many ways, but competition for light, nutrients, space and water represents their major effect on sugarcane locally.

Until recently, the principal weeds affecting Florida sugarcane were annuals, mainly grasses like Brachiaria plantaginea, Alexandergrass; Digitaria spp., crabgrasses; and, Eleusine indica, goosegrass. The important broadlef weeds were annuals readily controllable with timely applications of chlorophenoxy herbicides. The only common winter-spring broadleaf, Parietaria floridana, pellitoryweed, varied in local importance and could be controlled economically when necessary.

Sugarcane weed flora sugarcane has shifted perceptibly since 1965. Panicum adspersum, an annual grass has become common. It is not easily distinguished from Alexandergrass during seedling and juvenile stages and it is not readily controlled by Ametryne.

The most important recent change is the infestation of perennial grasses in sugarcane fields throughout the area. The dominantspecies is Pennisetum purpureum, Napiergrass (falsely called maidencane). Napiergrass is propagated by seed and stalk sections and may have been "planted" in some fields started with machine-harvested seedcane.

Considerable confusion revolves around the Sorghum species. It is doubtful that Sorghum halapense, johnsongrass, occurs widely or in local concentrations in the Florida sugarcane area. Plants which resemble johnsongrass, with erect panicles and rhizomes, probably are interspecific hybrids of an original johnsongrass population with sudangrass. Plants which resemble johnsongrass but lack rhizomes and have drooping panicles probably are *Sorghum sudanense*, sudangrass. The free hybridization of Sorghum species under field conditions would account for the composition, distribution and varying characteristics of the local infestations.

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[1] Plant Physiologist, Everglades Experiment Station - IFAS, University of Florida, Belle Glade, Florida 33430

Several *Panicum* species, fall panicum, guineagrass and witchgrass, occur throughout the local sugarcane area in several limited locations and with giant foxtail and coast cockspur, represent serious potential annual/perennial infestants.

Weed plants are responsive to the same ecological stimuli, especially moisture and temperature, which influence crop plant growth. Weed populations are not static and shift for adaptive survival under environmental pressure from natural sources like climate, diseases, insects and other plant pests and from applied sources like crops, cultural changes and chemical and mechanical control practices. A mixed population of spiny amaranth and nightshade may be converted to nightshade after repeated 2,4-D applications minimize or elminate the amaranth. Populations of 2,4-D resistant purslane and dalapon-resistant bermudagrass have developed under field spray programs. Weed shifts tend toward more agressive, more competitive, chemical-tolerant, perennial grasses; populations more difficult to control.

Problem weed species must be identified and control programs must relate to the weed in its ecological habitat. Control programs are directed to annual and perennial weed (broadleft, grass, sedge or mixed) populations using either preemergence or postemergence operations against the reporductive organs, seed or vegetative propagules, or seedling to mature plants.

The shift in local sugarcane weed flora probably was hastened by the rapid, widespread expansion of the industry by new, inexperienced growers over a wide geographical area and by inferior field and ditchbank sanitation.

WEED CONTROL METHODS

Preventive

Good management includes all sanitation practices which prevent entry of weed seed and weed plants into cropped areas. Wind and water-borne seed cannot be regulated, but the grower can control movement of plants, soil, equipment and supplies onto his land.

Cultural

Timely off-season tillage, fallowing and flooding followed by good seedbed preparation help to reduce weed problems. Flooding may be a mixed blessing in fields heavily infested with water-tolerant seed and in poorly prepared and inadequately flooded fields.

Mechanical

Tillage effectively controls many weeds, especially small annual seedlings, but must be timed for optimum weed control with minimal crop damage. Mechanical methods provide only transitory weed control; weed seed may begin to germinate immediately after cultivation when conditions are favorable.

Manual weed control, with hand hoes, can require 50 to 100 man-hours per acre in grass-infested fields. A short labor supply and increasing labor costs have long precluded manual weed control in all but exceptional circumstances.

In the plant crop, the traditional ridge-and-furrow planting system with disc and scratch cultivators is yielding to flat culture and more economical scratch and rolling cultivators. No cultural problems have been observed in more than 15 years of flat-planting in herbicide experiments. It is doubtful that effective in-row implements can be developed to supplement inter-row rotary tillage in ratoon crops.

Chemical

The options available for weed control are increased greatly by chemical herbicides. Herbicide programs may be adapted for short or long duration, foliage or soil treatment, quick contact or slow systemic action, selective or non-selective response and spray or granular application.

Chemical weed control is a complex, interacting biological-chemical system which includes the crop, the specific weeds, the specific herbicide and the plant environment. The objective of chemical weed control is to use a chemical or its metabolites to kill weeds without economic harm to the crop (or the environment). All chemicals and methods of application require a high degree of selectivity, the differential response of weeds and crops. Herbicide performance is affected by: dosage rate, time and method of application, climate and soil. Preemergence and preplanting herbicides are used as preventive insurance against anticipated weed problems and are more expensive. Postemergence herbicides are usually applied as foliar sprays in more economical corrective treatments for existing weed problems.

FLORIDA HERBICIDE EVALUATIONS

Herbicides useful in sugarcane production in other areas of the world may not be effective under the climatic and cultural conditions and the high sorptive capacities of Florida's organic soil. The following general pre- and postemergence methods with established varieties are used to develop Florida recommendations at the Everglades Experiment Station. Dandidate herbicidal chemicals are screened for weed control performance and annual field and vegetable crop response in primary evaluation trials. Chemicals which effectively control weeds, especially annual grasses, are then tested in primary sugarcane evaluations to confirm weed control activity and to assess sugarcane tolerance The most promising chemicals are placed in secondary evaluation trials to observe crop stand and growth responses (and sometimes yield) and weed control duration. Chemicals with promise of commercial development are tested in yield trials using replicated, 4-row, 1/50th acre plots which permit accurate determination of sugarcane stand, growth, yield and juice quality. Ratoon responses are evaluated and herbicidal treatments may be repeated on the same plots for several ratoons. Consistently superior chemicals with commercial labels or prospects of commercial labelling for sugarcane are tested in replicated one or two acre herbicide demonstration plots in grower fields for commercial harvest and final estimation of grower utility.

The program is sufficiently flexible to permit adding desirable chemicals at an intermediate step or to permit by-passing an early stage of the evaluations.

The experimental results reported in this communication are not intended to be nor should be construed as recommendations. Effective recommendations and specific details for sugarcane weed control are available in publications of the Everglades Experiment Station, the USDA Summary of Registered Pesticide Uses and the produce labels for herbicides "cleared" for sugarcane.

Preemergence small-plot experiments:

Typical results of replicated small-plot experiments are summarized in Tables 1, 2 and 3. It is difficult to simulate commercial cultivation in 0.01 and 0.02 acre plots with powered equipment because space is insufficient to develop ground speed necessary for good cultivation. Hand-weeded control plots are handcleaned with scuffle hoes supplemented by spray applications of chlorophenoxy herbicides. Hand operations are less rigorous and less damaging to cane than commercial cultivation and do not reflect yield-reducing injury from cultivation equipment.

Fenac was pplied preemergence and/or postemergence to the same plots of Cl. 41-223 sugarcane planted in twin-row beds for three successive crops. Better than commercially acceptable control of annual grass and broadleaf weeds was recorded. Cane yield did not differ among the chemical and control treatments (Table 1).

Other preemergence herbicide programs were applied in successive crops of Cl. 41-223 sugarcane planted in twin-row beds. All chemical treatments provided acceptable annual grass and broadleaf weed control and did not differ in yield from the control (Table 2).

The response of C.P. 50-28 sugarcane to four successive applications of preemergence herbicides is reported in Table 3 in pounds sugar per acre per month. The four crops were grown over a 47-month period. Sugar yield on a monthly basis is an effective means of compariing production efficiency. The chemical treatments reported effectively controlled annual grass and broadleaf weeds. Yields, as tonnage of cane or sugar per acre, did not differ significantly over the first three crops.

Results of the foregoing three experiments demonstrate that preemergence herbicides may be used to control annual grass and broadleaf weeds in sugarcane on organic soil without harmful effect on yield. Occasionally, late season application of chlorophenoxy herbicides may be needed for clean-up of broadleaf weeds in preemergence plots. Fenac has consistently provided partial control of annual grass weeds in the ratoon crop following treatment.

Postemergence small-plot experiments:

Tables 4,5,6 and 7 summarize typical small-plot trials with herbicides applied broadcast overall to emerged cane and weeds. General postemergence herbicides are applied at lower, more economical, rates than preemergence herbicides. But, a high degree of selectivity is needed to control weeds without injury to the crop.

Atrazine, Fenac and Karmex combination treatments applied to the same plots in three successive crops of Cl. 41-223 sugarcane planted in twin-row beds are summarized in Table 4. Karmex provided the most complete control of annual grass and broadleaf weeds but reduceded crop yield significantly or highly significantly each year. The Fenac and Atrazine combinations afforded better than acceptable control of annual grass and broadleaf weeds without affecting cane tonnage or juice quality.

Installation and management were similar for experiements with C.P. 50-28 sugarcane reported in Table 5 and Table 6. In one experiment, Fenac was applied preemergence to all plots in the first and second ratoons. In the third and fourth ratoons, preemergence-applied Fenac was continued in one treatment while various combinations of Fenac and 2,4-D were tested post-emergence to cane and weeds. Both the preemergence and postemergence applications were effective against annual grass and broadleaf weeds but the preemergence treatment repeatedly outyielded the postemergence treatments (Table 5).

Similarly, in another experiment, Limit was applied preemergence in the plant crop and Atrazine + Randox was applied preemergence in the first ratoon. In the third and fourth ratoons, Atrazine + Randox was continued in a preemergence treatment and various combinations of Atrazine + 2,4-D + surfactant were applied postemergence in other treatments. All treatments controlled annual grass and broadleaf weeds but the preemergence combination repeatedly outyielded the postemergence applications (Table 6).

The role of surfactants in postemergence herbicidal activity has been evaluated repeatedly. Results are clear-cut and dramatic on some occasions. Table 7 illustrates the response of C.P. 59-73 sugarcane to the same combinations applied in the plant and first ratoon crops. Weed control was equivalent in all combinations. Reduced plant damage and slightly higher yields were recorded for combinations including ACL 209 or ACL 210 surfactants. ACL 209 appears to be the "safest" surfactant tested. It may not be possible to predict a general optimal combination of herbicides and surfactants because performance is related to weed population, cane variety, rate of growth, season of year, dosage rates and other inconstant factors. Combination testing will continue to determine useful combinations which will control weeds without injuring cane.

Postemergence herbicde evaluation experiments have illustrated that certain combinations will effectively control annual grass and broadleaf weeds with no or minimal injury to sugarcane. Constituents of the combinations and their dosage rates determine safety. Postemergence herbicides should be applied off sugarcane foliage and directed to weed vegetation. Surfactant levels should be kept in the range 0.25 to 0.50 % v/v.

Semi-commercial scale experiments:

Experiments to simulate commercial herbicide usage have been conducted with plots 6- or 12-rows wide by one-quarter mile long (1 to 2 acres) or one-fifth acre plots. Three or more replications have been installed in grower's fields. Plots are cut by commercial crews and loaded and handled with conventional equipment.

Results of a typical trial with Cl. 41-223 sugarcane with largely recommended practices are summarized in Table 8. All chemicals afforded commercially acceptable annual grass and broadleaf weed control. The preemergence herbicides were slightly superior to the postemergence treatments especially in control of annual grasses. Cane tonnage and juice quality did not differ among these programs.

The effect of rate and method of Ametryne application was evaluated in adjacent plant and first ratoon fields of Cl. 49-198 sugarcane (Table 9). Semi-directed spray applications off the cane foliage effectively controlled annual grass and broadleaf weeds without effect on cane tonnage or sugar yield. High-rate semi-directed spray application caused visible damage to cane foliage and subsequent reduction of yield. Broadcast overall application of Ametryne, alone or in combination with Atrazine, 2,4-D or surfactant, injured the cane plant and reduced yield. Results with this variety parallel those in most other experiments: Ametryne may be used safely in low-dosage, semi-directed sprays which avoid setting crop foliage.

Napiergrass control experiments:

Napiergrass populations compete vigorously with sugarcane; stools ratoon along with sugarcane following harvest and grow at a rate equal to or slightly faster than sugarcane from March into summer. Stool area can increase rapidly by lateral growth until closein. Napiergrass seed apparently require warmer weather for germination, seedling growth and stool establishment. Seedling populations start to develop before closein and continue into summer. Napiergrass and sugarcane populations are interrelated: cane fields with good stand and vigorous growth appear to maintain a competitive advantage while cane fields with inferior stand and growth appear readily dominated by Napiergrass. Efficient herbicide evaluation is hindered by random distribution of Napiergrass populations in sugarcane fields.

Herbicides have been evaluated for fence-row and ditchbank weed control. Promising chemicals from these trials have been tested in several non-replicated "in-field" experiments. The relationship between Napiergrass population and cane tonnage within one field illustrated in Table 10 conforms to common observation that high Napiergrass populations denote low cane tonnages.

Napiergrass stools present in Cl. 41-223 sugarcane in April and May were treated with foliar-sprays of Ametryne. Cane tonnage at harvest appeared to be related to Napiergrass stool populations (Table 11).

Both soil sterilant and foliar-absorbed herbicides were employed in a non-replicated trial (Table 12). Chemicals were applied two or three times as spot-treatments in March, April or May to Napiergrass stool regrowth in a ratoon field of Cl. 41-223 sugarcane. Soil sterilant chemicals, with the exception of Pramitol granules, were applied at the rate of 5 to 10 stools per gallon solution; foliar spray chemicals were applied at the rate of 10 to 15 stools per gallon solution. Stools which survived an early treatment were retreated during subsequent applications. It is difficult to assemble firm conclusions from an experiment such as this one: there was no replication, Napiergrass stool infestation was not uniform, and there was no control over a summer seedling infestation of Napiergrass. Never-the-less, it is apparent that reduced can tonnages were associated with high Napiergrass populations at harvest and with certain chemicals which injured ratooning sugarcane. These experiments illustrate the three-fold or greater increase in Napiergrass stool population between closein and harvest.

SUMMARY

Weed competition is a common, obvious problem in sugarcane culture in Florida. In recent years, the weed flora has begun to shift from mainly annual grasses to a population which includes more hardy annual and perennial grasses. The shift has accompanied the expansion of the industry and inferior sanitation practices. In-field weed control programs apparently have had little effect on the floral shift. Both preventive and corrective weed control programs are available and most commercial sugarcane growers use a combination of methods, i.e., land tillage, flood fallow, mechanical cultivation and herbicides. Florida herbicide recommendations are developed in a stepwise process from small-plots to simulated commercial field plots. Effective pre- and postemergence weed control programs have been recommended and reported elsewhere. The largest immediate weed problem is an effective, selective control for Napiergrass and other hardy annual/perennial grasses which have begun to infest sugarcane fields.

ACKNOWLEDGMENTS

The sugarcane weed control experimentation reported herein was made possible through the generous cooperation of: Florida Sugar Corporation (Agriculture Department), Okeelant Division-Gulf and Western Food Products (Research Department), Sugar Cane Grower Cooperative of Florida (Agriculture Department), and United States Sugar Corporation (Agriculture and Research Departments).

Table 1. Yield response of Cl. 41-223 sugar cane planted in twin-raw beds on organic soil to preemergence-applied Fenac.

Herbicide and Rate lb./A ai	Tons Cane Per Acre		
	Plant	First R.	Second R.
Handweeded control	62.6	56.8	42.1
Fenac, 6 lb	57.6	54.1	42.0
Fenac, 9 lb	57.8	53.1	49.6*
Fenac, 6 lb delayed	60.3	49.2	42.8*
Fenac, 9 lb delayed	58.9	49.2	41.8*

NB. Two feet between rows, 10 feet between bed centers. Herbicides broadcast overall preemergence to weeds. Ratoon and delayed treatments broadcast over cane. (Asterisk (*) for second ratoon indicates 2 postemergence applications of (Fenac 2 _ 2,4-D 1 lb).

Table 2. Yield response of Cl. 41-223 sugarcane planted in twin-row beds on organic soil to preemergence herbicides.

Plant Crop		Ratoon Crops	First	Second
Herbicide and Rate/A	Tons cane/A	Herbicide and Rate /A	Tons cane/A	Tons cane/A
Handweeded control	58.7	Handweeded control	47.9	44.7
Limit, 2 gpa	56.5	Limit 2 gpa	46.9	40.4
Randox, 12 lb.	58.8	Randox, 12 lb.	48.8	39.5
Randox, 10 lb., no irrig.	56.9	Atrazine 4 + Randox 6 lb.	48.1	43.6
Randox, 10 lb. ½" irrig.	55.8	Ramrod, 10 lb.	51.9	48.1

NB. Two feet between rows, 10 feet between bed centers. Treatments broadcast overall preemergence to weeds. Ratoon sprays covered emerged cane foliage. Limit = a mixture of Randox 4 + 2,4-D 1 lb/gal. Rates in lb/A ai.

Table 3. Sugar yield response of C.P. 50-28 sugarcane to annual preemergence herbicide application on organic soil.

	Pounds Sugar per Acre per Month			
Herbicide & Rate lb/A ai	Plant	First R.	Second R.	Third R.
Handweeded control	624	646	897	487
Fenac, 6 lb.	609	695	954	551
Fenac, 9 lb.	604	652	974	598*
Limit, 3 pga	578	649*	974#	543#
Ramrod, 12 lb.	589	654*	903	445

NB. Limit = a mixture of Randox 4 + 2,4-D 1 lb/gal.

* = Only chlorophenoxy herbicides applied during this crop.

# = Atrazine 4 + Randox 6 lb applied these ratoons.

Table 4. Yield response of Cl. 41-223 sugarcane planted in twin-row beds on organic soil to postemergence-applied herbicides.

	Tons Cane per Acre		
Herbicidal & Rate/14 A ai	Plant	First R.	Second R.
Handweeded control	57.5	53.7	41.1
Atrazine 0.8 + 2,4-D 1/2 + S	58.6	53.5	39.6
Karmex 0.8 + 2,4-D 1/2 + S	52.3	33.7	22.7
Fenac 2 + 2,4-D 1	61.4	52.1	38.9

NB. Two feet between rows, 10 feet between bed centers. Treatments applied twice per crop, broadcast overall to cane and weeds. S = 1/2% v/v surfactant.

Table 5. Yield response of C.P. 50-28 sugarcane to annual herbicide application on organic soil

Plant Crop Fenac 9 lb/A preemergence	1st Ratoon Fenac 6 lb/A preemergence	2nd Ratoon	TCA	3rd Ratoon	TCA
37.0 TCA	52.2 TCA	Fenac 6	54.6	Fenac 6	27.8
35.6	53.5	*Fenac 1 + 2,4-D 3	49.4	*Fenac 1 + 2,4-D 3	23.7
33.9	53.6	*Fenac 1 + 2,4-D 2	50.6	*Fenac 1 + 2,4-D 2	23.8
37.9	54.3	*Fenac 2 + 2,4-D 2	50.0	*Fenac 2 + 2,4-D 2	23.7
36.9	55.6	*Fenac 2 + 2,4-D 1	49.9	*Fenac 2 + 2,4-D 1	25.6

* = Combinations of fenac and 2,4-D applied twice, postemergence, broadcast overall to sugarcane and weeds. Rates in lb/A ai.

Table 6. Yield response of C.P. 50-28 sugarcane to annual herbicide application on organic soil.

Plant Crop Limit 2 gpa preemergence	1st Ratoon Atrazine 4 Randox 6 lb preemergence	2nd Ratoon	TCA	3 Ratoon	TCA
27.7 TCA	52.9 TCA	Atra 4 + Rand 6	57.4	Atra 4 + Rand 6	33.1
28.8	52.7	*Atra + 2,4-D 1/2	52.8	**Atra 0.8 + 2,4-D	30.6
28.2	53.6	*Atra + 2,4-D 1	53.5	**Atra 1.6 + 2,4-D	30.0
29.2	53.5	*Atra + 2,4-D 1½	52.3	**Atra 2.4 + 2,4-D	32.1
30.3	53.1	*Atra + 2,4-D 2	51.7	**Atra 3.2 + 2,4-D	31.2

NB. Combinations of atrazine and 2,4-D applied twice, postemergence, broadcast overall to sugarcane and weeds. Rates in lb/A ai.

* = Atrazine 9.8 lb + 2,4-D + surfactant 1/2% v/v.

** = Atrazine + 2,4-D 0.75 lb + surfactant 1/2% v/v

Table 7. Influence of surfactant in Atrazine-2,4-D combinations on C.P. 59-73 sugarcane response.

	Plant Crop					Frist Ratoon		
Herbicial Treatments	Number Dead Heart	Cane Toler-ance	Stalk Length cm.	Cane Yield TCA	Sugar Yield lb/plot	Stalk Length cm.	Cane Yield TCA	Sugar Yield lb./plot
Atrazine + 2,4-D + ACL 209	0.4	92%	180	50.4	195	211	37.2	124
Atrazine + 2,4-D + ACL 210	2.2	95	184	51.5	199	215	36.8	117
Atrazine + 2,4-D + X-114	24.4	85	178	48.2	187	206	36.5	111
Atrazine + 2,4-D + Surf WK	20.0	82	184	49.7	190	205	35.8	117

NB. Atrazine 0.8 lb. + 2,4-D 0.5 lb/A ai + surfactant 1% active v/v applied in 30 gpa water.

Table 8. Response of Cl. 41-223 sugarcane to herbicide programs under semi-commercial conditions.

Plant Crop		First Ratoon	
Herbicide and Rate/A ai	TCA	Herbicide and Rate/A ai	TCA
Cultivation + 2,4-D & 2,4,5-T	42.7	PRE Atrazine 2.1 + Ramrod 4.8 lb	29.6
PRE Fenac 9 + 2,4-D 1 lb	44.6	POSO Fenac 1½ + 2,4-D 1 lb	34.4
PRE Eptam 5½ + 2,4-D 1½ lb	43.7	POSD Ametryne ½ + 2,4-D ½lb + S	31.5
PRE Atrazine 4 + Ramrod 6½ lb	43.9	POSD Dalapon-M 4 _ 2,4-D 1½ lb	32.9
POSO Atrazine 1 + 2,4-D ½ lb + S	41.8	POSO Atrazine 1 + 2,4-D ½ lb + S	29.3
POSO Atrazine 1 + 2,4-D ½ lb +**	42.5	POSO Atrazine 1 + 2,4-D ½ lb + **	32.2
POS* Ametryne ½ + 2,4-D ½ lb	40.7	POSD Ametryne ½ + 2,4-D ½ lb + S	29.0
POS* Dalapon 3 + 2,4-D 1½ lb	39.0	POSD Dalapon 4+ 2,4-D 1½ lb	31.5

NB. PRE indicates a single preemergence application at planting or ratooning. All postemergence treatments applied twice. POSO = Postemergence overall to cane and weeds. POSD = postemergence directed sprays to wet weeds but avoid most cane foliage. POS* = first application overall and second application directed. ** = Sun 11E phytobland oil at 2 gpa. S - surfactant X-100 or X-114 at ½% v/v.

Table 9. Plant and ratoon Cl. 49-198 sugarcane and weed response to Ametryne applied postemergence in semi-commercial-scale replicated plots.

Postemergence Combinations				Cane Tolerance		Weed Control		Tons Sugar/Acre	
Amet- + ryne	Atra- + zine	2,4-D + amine	X-114 %	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
Semi-directed, skid applied									
1/2	--	1/2	1/2	92%	87%	91%	97%	5.33	5.22
1	--	1/2	1/2	81	78	97	100	5.08	4.76
2	--	1/2	1/2	56	65	97	100	4.68	4.42
Broadcast overall									
1/4	1	1/2	1/2	84	92	87	100	4.76	4.79
1/2	1	1/2	1/2	72	78	91	100	4.64	4.31
1/2	--	1/2	1/2	69	75	91	100	4.53	4.47
1/2	--	--	1/2	72	75	91	100	4.65	4.21
1/2	--	--	--	84	81	87	91	4.97	4.59
--	1	1/2	1/2	96	96	94	97	5.24	5.13

NB. All treatments applied twice. Rates in lb/A ai except surfactant in % v/v.
Plots 6 rows wude by one-quarter mile long, replicated 4 times.

Table 10. Relationship between Napiergrass populations and yield of Cl. 41-223 sugarcane in untreated control plots.

	Napiergrass Stools		Pounds
Plot Designation	in Spring	at harvest	Cane/Plot
A-8	30	223	25,520
B-13	138	949	15,660
C-18	151	1162	10,820
D-24	311	795	12,500

NB. Plots 4 rows wide x 1/4 mile long.

Table 11. Relationship between Napiergrass populations and yield of Cl. 41-223 sugarcane in Ametryne-treated plots.

	Napiergrass Stools		Pounds
Herbicidal treatment	at Treatment	at harvest	Cane/Plot
"Ametryne 80W"	0	1	48,520
at 40 lb product	2	11	39,880
per 100 gal water	8	34	32,360
as foliar sprays	18	80	30,680
in April and May	30	13	37,380

Table 12. Napiergrass and Cl. 41-223 sugarcane response to soil sterilant and foliar spray spot application of herbicides for Napiergrass control

Herbicide and Rate of Application	Date Applied 22 Mar	 23 Apr	 13 May	Number Stools at Treatment	 Harvest	Pounds Cane/Plot
Soil Sterilants						
"Pramitol 5G" 2 cups/stool		x	x	80	337	27,460
"Pramitol 5G" 2 cups/stool	x		x	56	377	28,900
"Karmex" 20 lb/100 gal water		x	x	88	357	27,220
"Karmex" 20 lb/100 gal water	2		2	196	540	27,140
"Telvar" 20 lb/100 gal water		x	x	143	486	21,080
"Telvar" 20 lb/100 gal water	x		x	92	371	29,140
"Hyvar-X" 20 lb/100 gal water		x	x	303	687	12,300
"Hyvar-X" 20 lb/100 gal water	x		x	365	342	11,120
"Sinbar" 20 lb/100 gal water		x	x	115	489	24,220
"Sinbar" 20 lb/100 gal water	x		x	154	356	17,760
"Monobor-Chlorate" 100 lb/100 gal		x	x	279	975	11,760
"Chlorbor-D" 100 lb/100 gal water		x	x	282	679	13,540
"Hibor" 100 lb/100 gal water		x	x	322	682	12,160
Foliar Sprays						
"Dowpon" 10 lb/100 gal water		x	x	284	806	14,780
"Dowpon-C" 10 lb/100 gal water	x	x	x	283	961	16,700
"Kuron" 10 qt/100 gal diesel oil	x	x	x	345	878	21,480
"Weed-E-Rad + W" MSMA						
5 gal/100 gal water on	x					
plus 5 qt/100 gal water on		x	x	356	869	21,320

NB. Plots 4 rows wide x 1/4 mile long, not replicated. Rates in terms of commercial product.

RESEARCH IN MECHANICAL HARVESTING AND CLEANING OF SUGARCANE IN FLORIDA 1/

By Joe E. Clayton and Hiram D. Whittemore 2/

The present USDA Sugarcane Harvesting Project was moved to Belle Glade, Florida in 1965. During the same year the Long Vegetable Fibers Harvesting Project was phased out and the personnel and facilities were made available for sugarcane research. From 1944 to 1964 the Sugarcane Harvesting Project was located at the U. S. Sugarcane Field Station at Houma, Louisiana, where about 90 percent of the research efforts was devoted to harvesting and 10 percent to planting.

At the time the research started in Florida, the only harvesters being tried were the Louisiana soldier-type doing contract cutting and the U. S. Sugar Corporation recumbent sugarcane harvester. The Cary harvester had been tried briefly. The major obstacles at this time were poor pickup efficiency and poor regrowth of stubble. For historical purposes we should remember that several harvesters were tried in Florida sugarcane about 1930.

The USDA harvester research is dedicated to solving harvesting problems in Florida, Louisiana, Puerto Rico and Hawaii. The following problem areas have been studied since 1965:

I. Best method of cutting the stalk at the ground
II. Methods of gathering and lifting recumbent sugarcane
III. Removing immature tops from recumbent sugarcane
IV. Cleaning sugarcane in bulk while conveying
V. Methods of chopping into uniform lengths

1/ For presentation at the Florida Division of the American Society of Sugar Cane Technologists, Palm Beach, Florida, October 15, 1970.

2/ Agricultural Engineers, Sugarcane Harvesting Investigations, Agricultural Research Service, USDA, Belle Glade, Florida.

This research is supported by public funds and a major effort is being made to do the research that is not being done by machinery manufacturers (1). Frequest contact with engineers and producers is made to keep research current. An Industry Sugar Cane Harvesting Committee was formed in 1963 to help set priorities of research in the four production areas.

It was found that the base cutters of some harvesters from Louisiana were uprooting 50% of the stubble in Florida sugarcane. Research in 1965 and 1966 with twelve types of circular cutters provided some answers. By use of high-speed photography, it was found that the tip speeds of 3,000 feet per minute of most cutters was too slow. As a result, cutting tip speeds of 5,000-6,000 feet per minute with heavy duty mower sections mounted each 60 degrees around the disc was recommended (2).

A simple, slow-moving recumbent sugarcane pickup component using two horizontal augers was designed and tested from 1966 through 1968. The objectives were to remove all chains in contact with cane and trash and replace with revolving components that would not wrap and choke.

Two pickup systems were tested; one using a pair of 20-inch diameter auguers and one using a 30-inch diameter upper auger and an 18-inch diameter lower auger. The auger flights laid any standing cane over as it was cut at the ground by a circular disc. The lower auger picked up the mat of cane and it was chopped into short pieces by the meshing flights as the cane was fed between the augers. The end discs on the augers cut the harvested row away from the adjacent field. These systems harvested cane at 50 to 100 tons per hour with a very low horsepower requirement (3).

Figure 1 is a typical Florida field of recumbent sugarcane. Figure 2 is a field that has been burned. In Figure 3, the cane has been separated from the trash and the tops.

Since 1968, research has been concentrated on removing immature tops, suckers, leaf trash and other unwanted material from sugarcane. Considering that all cane tops turn vertically towards the sun, a system was developed to lift and sever the tops. A set of 18 rubber rolls was operated over the mass of tops to remove the tops by the snapping action or cut them at the rear of the rolls. In recumbent sugarcane fields, the rolls generally operated at about two feet above the ground. Approximately 50 percent of the tops were contacted and only half of these were properly topped. This was not satisfactory, considering the power being used.

Research on cleaning trash from chopped sugarcane began in 1964 with a research contract at the Louisiana State University Agricultural Engineering Department. Polygon shaped rolls developed there were tested in Florida. These principles of cleaning could be applied on a harvester, at a transfer station or at a mill (4). Figure 4 is a polygon cleaner using square rolls.

The most efficient of the polygon rolls have been the 5-inch diameter hexagonal rolls. Six-inch diameter spiral rolls have been equally efficient for chopped cane (Figure 6). Both of these rolls have been operated alongside a harvester and reduced the trash content from 20 percent to 8 percent on the average.

Rubber husking rolls have been more efficient than the steel rolls in removing the immature tops (Figure 5). These 3-inch diameter rolls have been mounted in a semicircle with an auger conveying the cane pieces over the rolls. They have cleaned cane to about 5 percent trash content but are not as easy to operate as the larger diameter rolls.

One disadvantage of rolls is the fact that some good cane is lost. Some of the loss comes about in trying to snap an immature top from the mature cane pieces. Some of the loss is at the discharge bearings of the rolls.

Research is continuing with methods of cleaning using agitating cylinders, air blasts and other systems. It is felt that cleaning may have to be done at several conveying points in Florida to remove sufficient trash. A mill sample cleaner and a spiral roll cleaner will be tested in Louisiana this season.

Where Do We Stand on Mechanical Harvesting Today?

As you can see in Table 1, we have not been harvesting much cane mechanically. However, significant progress is being made in developing principles of harvesting, chopping and cleaning. The harvesting systems used by two plantations last year performed reasonably close to expectations. We feel that with some improvements in field conditions and trash elimination, the crop can be harvested mechanically.

There are many field conditions that are not conducive to mechanical harvesting. As each plantation begins to experiment with the harvesters, additional problems will undoubtedly be uncovered. For instance, it is recognized that muck fires started by field burning won't be reached by mechanical harvesters as soon as they would be in hand harvested fields. Also recognized is the increased compaction of the soil by many passes of a harvester and wagons. These may be future problems. Since it generally takes five years to replant all fields and get changes made, these experiments should start at once.

Mechanical harvesting will make us more vulnerable to losses from hurricane and freeze damage and there will be more lost time due to rain. We are working hard, along with producers and manufacturers, to mechanically harvest cane and remove as much of the trash as possible. We hope that the mill engineers are equipped to handle their half of the trash or soil problem so that mill capacities will not be drastically reduced, along with net income.

Future Problems Needing Research

1. Harvesting and cleaning cane for planting
2. Mechanically planting
3. Harvesting cane without burning
4. Moving trash away from stationary field or mill cleaners

TABLE I. Sugarcane Harvested by Experimental Machines in Florida.

YEAR	PERCENTAGE
1964	0.5
1965	1.2
1966	1.5
1967	0.8
1968	1.2
1969	2.4

TABLE 2. Trash Content of Sugarcane in Florida.

YEAR	FIELD	MECHANICAL HARVESTING	MILL CANE
	%	%	%
1964	22.0	15.2	5.2
1965 Early*	32.0	25.4	13.9
1965 Late	23.8	17.5	6.4
1966	20.0	13.7	5.6
1967	23.9	8.5	5.0
1968	32.0	9.5	4.8
1969	37.8	13.4	5.0

* Unburned seed cane

References

(1) Immature Trash in Florida Sugar Cane Causes Harvesting Problems, by Joe E. Clayton and Hiram D. Whittemore, Sugar y Azucar, July 1969.

(2) Evaluation of Circular Cutting Systems on Sugarcane Harvesters Using High-Speed Photography, by Joe E. Clayton and Hiram D. Whittemore, ARS 42-155, June 1969.

(3) Research on Systems for Harvesting and Cleaning Recumbent Sugarcane, by Joe E. Clayton, Sugar y Azucar, July 1968.

(4) Basic Studies on Mechanical Detrashing of Bulk Sugarcane by Billy J. Cochran and Joe E. Clayton, I.S.S.C.T. Proceedings, Twiwan, 1969.

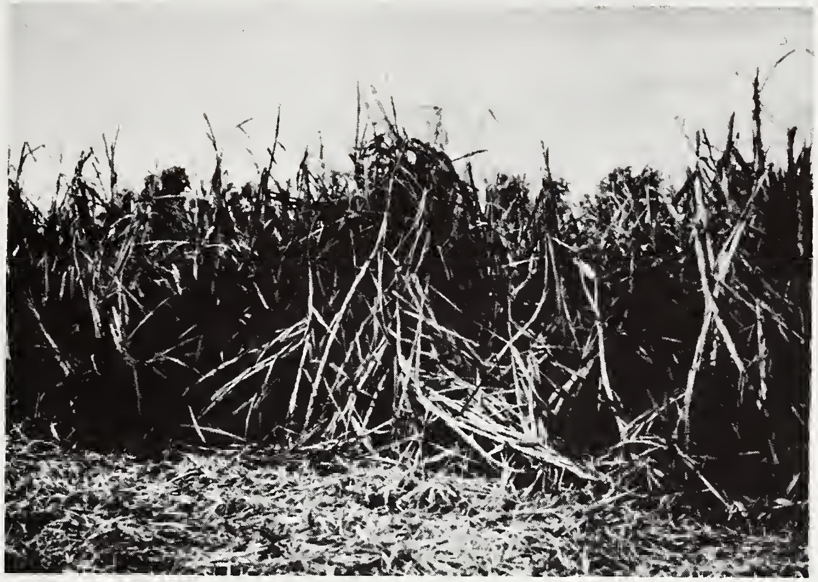


Figure 1 Unburned field of recumbent sugarcane.

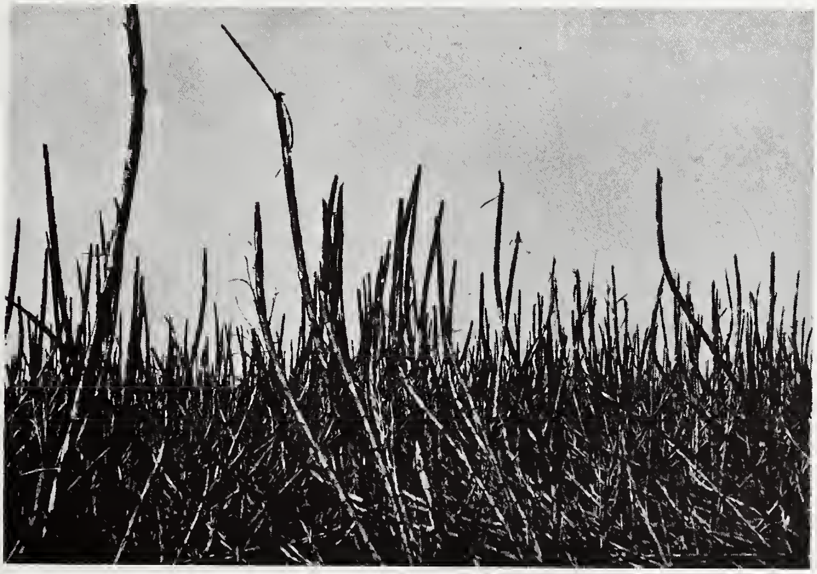


Figure 2 Burned field of recumbent sugarcane.

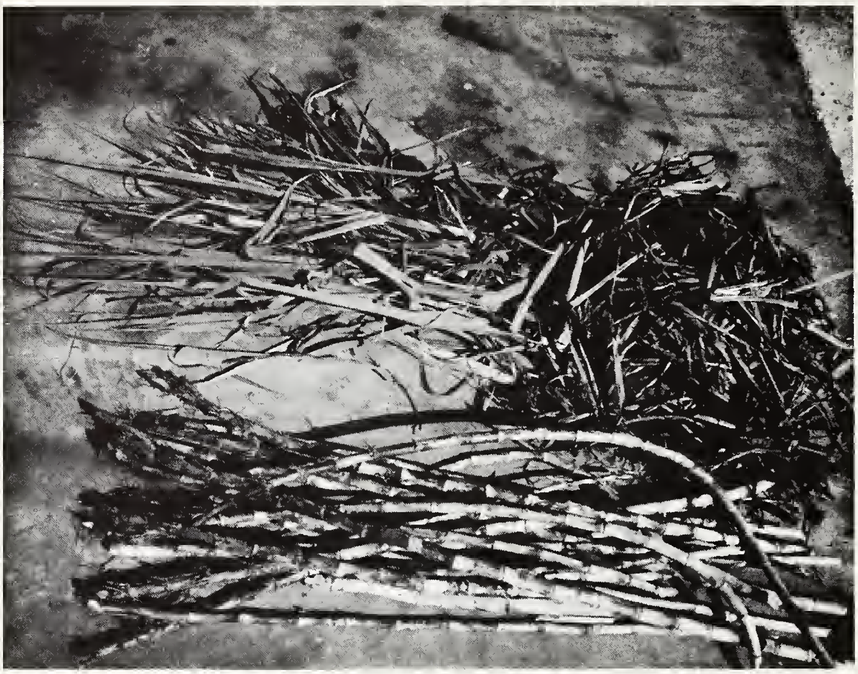


Figure 3 Field sample of sugarcane. Top and suckers upper left, trash upper right. Cane foreground.

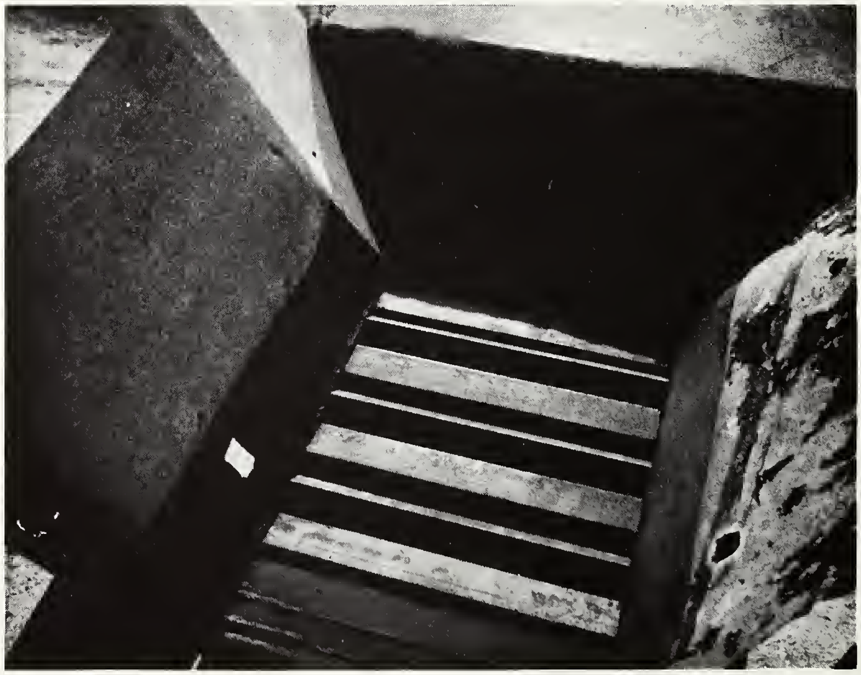


Figure 4 A cleaner using square tubing rolls.

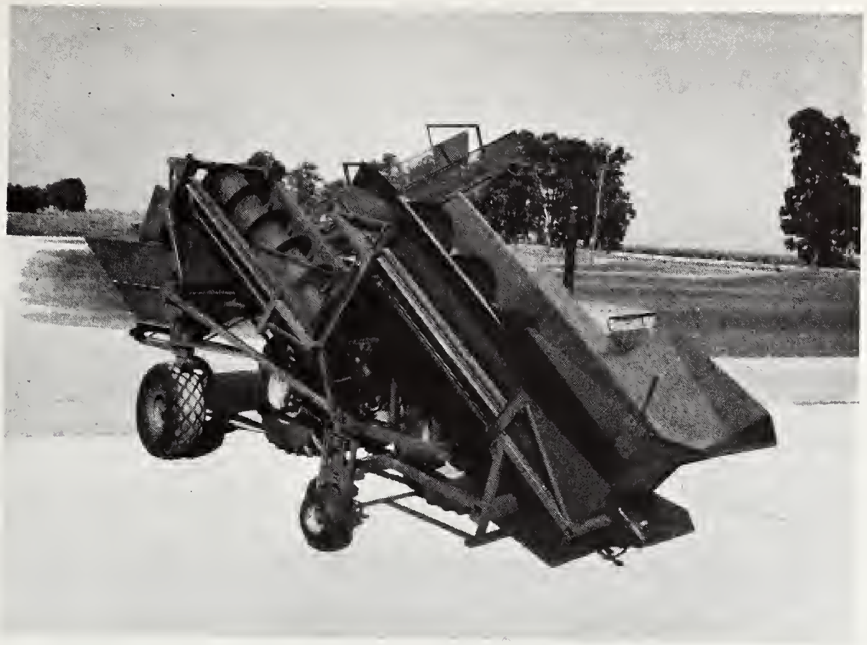


Figure 5 Two husking roll cleaners mounted for field use. Augers move the cane over the husking rolls.

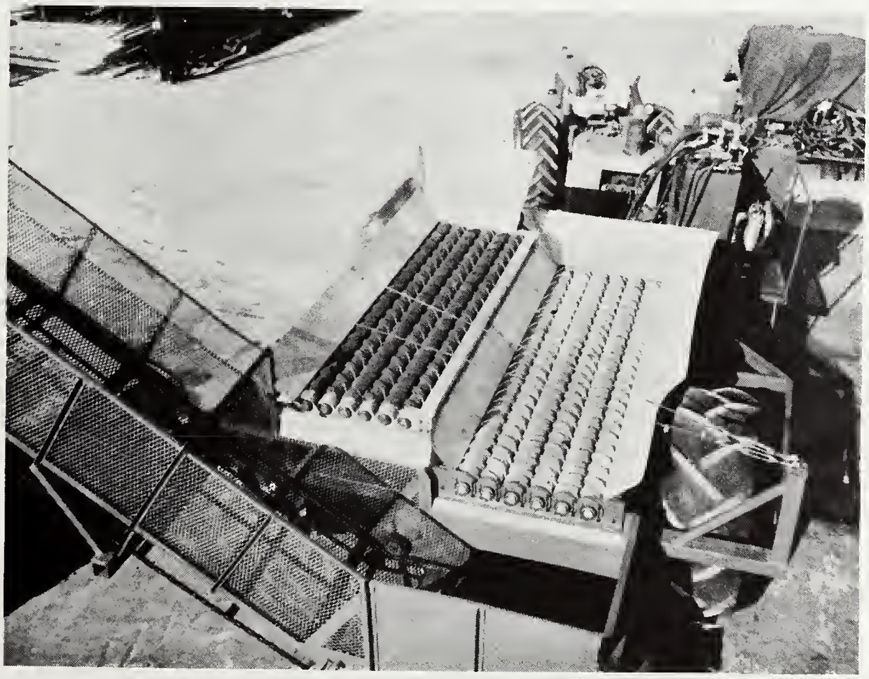


Figure 6 Steel (left) and aluminum (right) spiral roll cleaners. Rolls remove trash and spirals move the cane.

STATUS OF AIR QUALITY IN THE SUGAR CANE AREA OF FLORIDA

E. R. Hendrickson, Ph.D., P. E.
Environmental Engineering, Inc.
Gainesville, Florida

INTRODUCTION

Ambient air studies of limited scope plus theoretical emission and dispersion calculations conducted during 1967 and 1968 by personnel of the Palm Beach County Health Department led to the contention that the sugar industry was a major contributer to polluted air in southeast Florida. These calculations led the air pollution control authorities to conclude that the industry was responsible for more than 25 percent of the "total air pollution" and more than 95 percent of suspended particulates. Based on sampling for suspended particulates at 3 stations they concluded that the sugar cane growing area was substantially higher than other areas of Palm Beach County, and that the levels increase significantly during the harvesting season.

Based on the observations which were made, the state pollution control authorities served notice on the 9 operating mills that they were in violation of existing regulations. This action set off a round of source evaluation and the development of an extensive air quality improvement program on the part of the Florida Sugar Cane League, Inc. The source sampling revealed that all boilers in the industry were exceeding the existing process weight limitations of the state regulations when burning bagasse. This regulation should not be applied to a combustion source since it originally was developed for application to metallurgical furnace fumes. The application to bagasse boilers represents an arbitrary extrapolation from a completely different type of source, it is not related to reduction of some undesirable condition in the environment, the size of particles emitted from bagasse furnaces is such that they are largely non-respirable, and the majority of the weight of the particles falls out on farmland owned by the growers. These preliminary observations raised doubt as to the validity of the official claims.

The Florida Sugar Cane League, Inc. retained Environmental Engineering, Inc. and David B. Smith Engineers, Inc. as a joint venture to plan and conduct an air quality improvement program. The program included continuation of the bagasse boiler emission evaluation, pilot plant studies of devices for reduction of particulate emissions from the boilers, evaluation of the magnitude of particulate emissions from cane field burning, and an ambient air survey for particulates and sulfur dioxide. Concurrently the Florida Agricultural Experiment Station conducted an evaluation of alternatives to cane field burning. This paper reports the results of the ambient air survey.

PROJECT DESIGN

Working in close coordination with the state and county regulatory agencies, the League developed and implemented a massive ambient air study covering the entire Florida sugarcane growing and processing area. The study which started in September, 1969, and continued through May, 1970, encompassed pre-season, season, and post-season conditions. The major objective of the ambient air study was to evaluate the air quality of the area, including rural as well as populated centers. It also was intended to estimate the influence of sugar harvesting and mill operations on the air quality.

The ambient air survey involved a meteorological network, a sampling network for suspended and settleable particulates, a sampling network to monitor sulfur oxides, aircraft sampling, a sub-system for reporting time and location of field burning, and a correlation program.

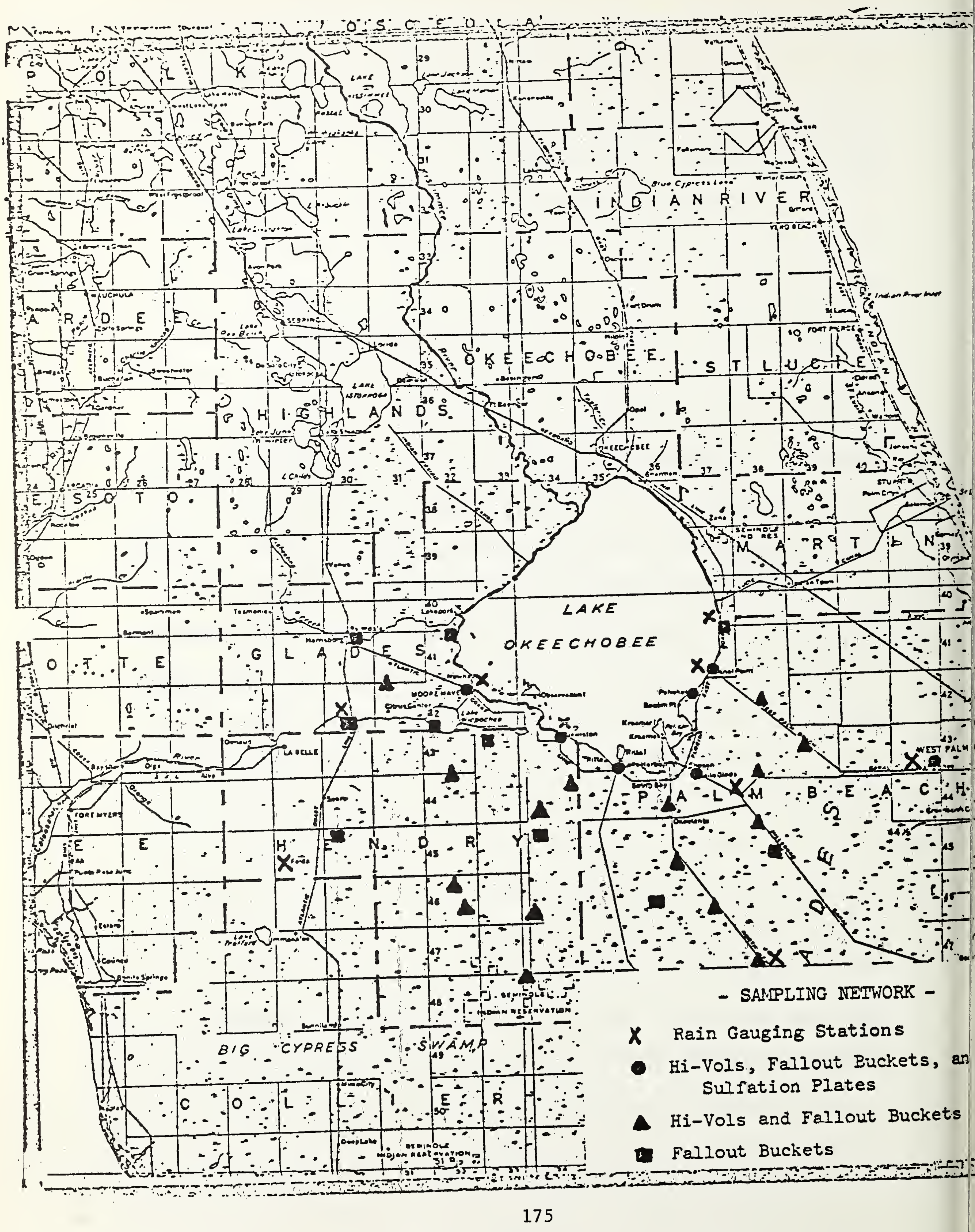
Meteorological stations in the area were considered to be atypical because of their location and the location of possible obstructions. A site was selected south of Okeelanta which was considered to be more typical of the entire sugarcane growing area. A meteorological station consisting of a recording wind direction and velocity unit was installed at this location. Hourly average figures were tabulated for both wind direction and velocity. Each month a windrose was constructed. Rainfall data were collected from several other meteorological stations in the area.

Thirty-four ambient air sampling sites were selected in the tri-county area. These initially were located on a grid network which was later modified by field investigation. Final location depended on access, siteconditions, security, and availability of electricity.

Eight of the sites were in urban areas, located on the rooftops of buildings, and twenty-six were in rural areas on power poles. Figure 1 shows the location of individual stations.

All thirty-four stations were equipped with dustfall buckets to measure the settleable particulate concentration accumulated during a 30-day exposure. The technique used is that essentially described in "Standard Method for Collection and Analysis of Dustfall," ASTM Designation D 1739-62. All samples were analyzed for insoluble particulates and water soluble particulates. The dustfall rate was determined by dividing the container opening area into the weights of soluble and insoluble particulates collected over a period of thirty days. Thirteen representative samples were sent to Walter C. McCrone Associates, Inc., for morphological examination to estimate the portion of each sample what was attributable to cane burning and boiler stack emissions as opposed to other settleable particulate matter. These samples were selected to show conditions during period of burning and non-burning.

The eight urban stations, plus sixteen of the rural stations were equipped with high-volume samplers which collected suspended particulates during a 24-hour period. The Hi-Vols were operated once every fourth day during the survey period. The procedure used was essentially that described in "Recommended Standard Method for Atmospheric Sampling of Fine Particulate Matter by Filter Media--High-Volume Sampling," APM-2.5, APCA Committee TR-2. The samplers used were Curtin Model 1105-3C which were equipped with an on-off


OSCEOLA
POLK
INDIAN RIVER
HARDEE
OKEECHOBEE
ST LUCIE
HIGHLANDS
DESOTO
MARTIN
LAKE OKEECHOBEE
CHARLOTTE
GLADES
PALM BEACH
LEE
HENDRY
BIG CYPRESS SWAMP
COLLIER
SEMINOLE INDIAN RESERVATION
- SAMPLING NETWORK -
X Rain Gauging Stations
● Hi-Vols, Fallout Buckets, an
Sulfation Plates
▲ Hi-Vols and Fallout Buckets
■ Fallout Buckets

timer and recording flow meter. The flow recorder was calibrated with a certified calibration orifice. Air samples were filtered through a Type A fiberglass filter at a rate of 30 - 50 CFM. The suspended particulate concentration was determined by dividing the filtered particulate weight by the metered air volume. Prior to weighing, filters were equilibrated in a special humidity and temperature controlled room for twenty-four hours. Twenty-three of the high-volume samples collected during the entire season were also subjected to a morphological examination by Walter C. McCrone, Associates, Inc. Those from the eastern part of the county were selected to show influence of west winds.

At the eight urban stations, sulfation rate was also monitored during the survey. The Huey sulfation plate was utilized for this purpose. Exposure was for the same period as the dustfall samplers. At the end of thrity days exposure, the samples were analyzed for the sulfation rate which is related to the sulfur dioxide concentration.

On several occasions, an instrumented airplane traversed the smoke plumes resulting from cane field burning. The instrumentation made it possible to estimate the particle size distribution in the plume at various altitudes and various distances from the burning field. Photographs also were taken of the field which was sampled.

In order to evaluate the different conditions which prevail during the season when burning operations take place, and when burning operations are not conducted, the sampling period started in September and ended in May. Field burning began during the latter half of November and ended about mid-March.

DISCUSSION OF RESULTS

Settleable Particulate Data. Settleable particulate matter usually is considered to be that fraction greater in size than 10 microns. Interpretation of the results of these measurements leaves much to be desired. It is usually considered to be a very gross measure of the general dirtiness of a community. Typical values for U. S. cities range from 10 to 100 tons per square mile per month.

Geometric mean concentrations for all thirty-four stations during the entire sampling period ranged from a low of 5 tons/mi^2/mo to a high of 22 tons/mi^2/mo. Stations were grouped as eastern stations (stations in Palm Beach County) and as western stations (stations in Hendry and Glades counties). The geometric mean values for the entire season were 12 tons/mi^2/mo for eastern stations and 8 tons/mi^2/mo for western stations. The geometric mean value for all stations during the sampling period of September, 1969, through May, 1970, was less than 10/tons/mi^2/mo. Data from the Palm Beach County Health Department indicates that lower concentrations are experienced during the summer months, therefore, the mean value of less than 10 tons/mi^2/mo would probably have been reduced if the summer months would have been included in the sampling period.

Results of the morphological examination revealed that the amount of burned plant material in the samples taken during the burning season ranged between 11 and 47 weight percent. During the season when cane was not being burned, the value ranged from less than 1 to 43 weight percent. The category of "burned plant material" includes not only particulates resulting from cane processing operations, but also particulates from any vegetation which is burned intentionally or accidentally.

The levels observed are generally acceptable in residential areas. Very little data relating to effects as measured by settleable particulates can be found.

Suspended Particulate Data. The category of suspended particulate matter to some extent, is defined by the method of collection and analysis. Using the Hi-vol filter and glass fiber filters, the size range is about 0.1 to less than 100 microns. Suspended particulates, in appropriate concentration, have been related to human health effects, materials damage, and visibility interference. According to the criteria document of the National Air Pollution Control Administration the minimum levels at which adverse effects have been noted include: 80 to 100 micrograms per cubic meter ($\mu g/m^3$) in the presence of sulfation rates exceeding 30 $mg/cm^2/mo.$ - increased death rates for persons over 50 may occur; 60 to 180 $\mu g/m^3$ in the presence of sulfur dioxide and moisture - corrosion of steel and zinc panels occurs at an accelerated rate; about 150 $\mu g/m^3$ (where predominant particle size ranges from 0.2 to 1 micron) and relative humidity is less than 70 percent - visibility may be reduced to as low as 5 miles. All values except that for visibility are annual geometric means. The concentration for visibility is a 24-hour observation.

Observed values in near-urban and urban areas range from about 60 to 200 $\mu g/m^3$ annual geometric mean. Individual 24-hour observations may vary 300 to 700 percent from the mean.

The first field burning began on November 11, 1969, and continued on through March 22, 1970. During this time approximately 138,120 acres of sugar cane was burned. Based upon field burning data, 23 percent of this total acreage was burned on days that suspended particulate samples were being taken. The number of sample days during the time this acreage was burned represented about 25 percent of the total number of days during the entire burning season.

Maximum, minimum, and geometric mean concentrations of the suspended particulate data are shown in Table 1, which includes a differentiation between burning and non-burning conditions. During the burning season the geometric mean concentrations for all twenty-four stations ranged between 22 and 70 $\mu g/m^3$. The range of concentrations for the non-burning season was between 26 and 100 $\mu g/m^3$. The geometric mean concentration of all stations operating during the burning season was 39 $\mu g/m^3$, and during the non-burning season it was 44 $\mu g/m^3$. The range of suspended particulate concentrations in which most burning and non-burning samples fell was between 10 and 50 $\mu g/m^3$ as shown in Figure 2.

As previously mentioned, the stations were separated into eastern and western groups. The geometric mean concentration for suspended particulate in the eastern stations was 48 $\mu g/m^3$, and in the western stations it was 32 $\mu g/m^3$. When all data were evaluated for both burning and

TABLE 1

HI-VOLUME AIR SAMPLER DATA

	Suspended Particulate Concentration, $\mu g/m^3$											
	Burning Season*				Non-Burning Season**				Entire Season***			
Sta. No.	Max.	Min.	Geo. Mean	No. of Samples	Max.	Min.	Geo. Mean	No. of Samples	Max.	Min.	Geo. Mean	No. of Samples
1	85	31	56	34	77	40	57	19	85	31	56	53
2	41	8	25	32	40	9	26	22	41	8	25	54
3	177	12	34	34	92	14	33	33	177	12	34	67
4	152	27	70	26	183	18	69	28	183	18	69	54
5	138	15	60	34	112	20	49	32	138	15	54	66
6	56	18	34	23	57	16	28	14	57	16	32	37
7	89	27	50	20	105	25	48	21	105	25	49	41
8	262	13	48	29	99	12	40	29	262	12	44	58
9	133	17	45	32	84	18	59	19	133	17	50	51
10	150	18	68	31	181	25	61	19	181	18	65	50
11	80	19	45	23	102	24	45	18	102	19	45	41
12	129	19	54	29	344	32	100	16	344	19	67	45
13	142	28	70	20	152	33	86	19	152	28	77	39
14	135	21	43	32	100	28	50	16	135	21	46	48
15	130	19	42	33	145	24	50	19	145	19	45	52
16	78	21	37	16	105	27	58	19	105	21	47	35

- continued -

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* Nov. 12, 1969, through Mar. 20,1970

** Sept. 10, 1969, through Nov. 8, 1969, and Mar. 24, 1970, through May 31, 1970

*** Sept. 10, 1969, through May 31, 1970

TABLE 1 (CONTINUED)

HI-VOLUME AIR SAMPLER DATA

	Suspended Particulate Concentration, $\mu g/m^3$											
	Burning Season*				Non-Burning Season**				Entire Season***			
Sta. No.	Max.	Min.	Geo. Mean	No. of Samples	Max.	Min.	Geo. Mean	No. of Samples	Max.	Min.	Geo. Mean	No. of Samples
17	100	13	44	22	158	32	73	14	158	13	54	36
18	49	8	27	29	51	14	32	16	51	8	29	45
19	88	18	28	23	47	12	30	18	88	12	29	41
20	51	7	26	33	49	12	30	18	51	7	27	51
21	46	10	22	30	44	10	26	18	46	10	24	48
22	237	8	29	32	550	18	43	18	550	8	33	50
23	48	14	23	29	51	19	28	17	51	14	25	46
24	42	8	25	26	43	12	27	15	43	8	26	41

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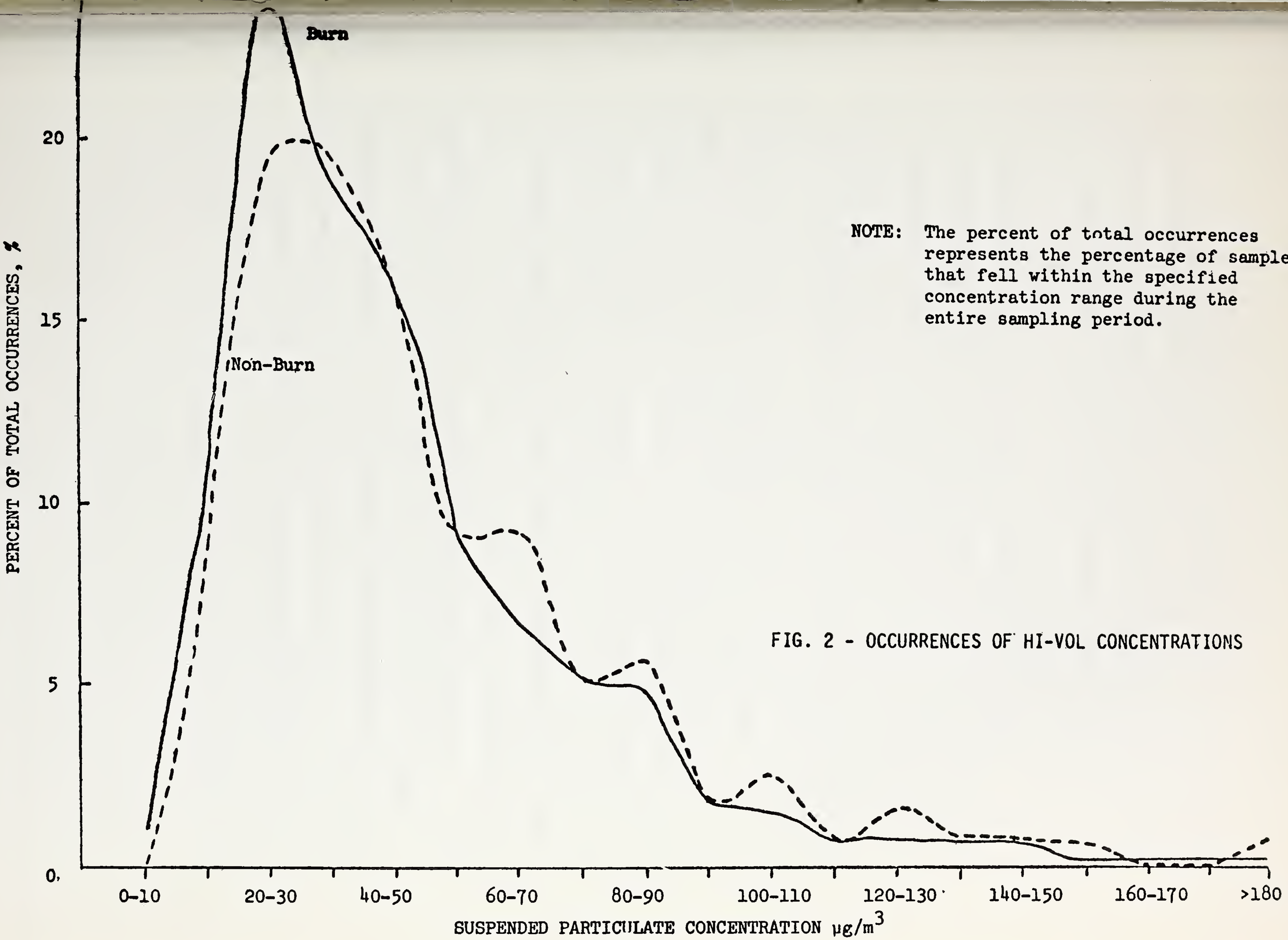
* Nov. 12, 1969, through Mar. 20, 1970

** Sept. 10, 1969, through Nov. 8, 1969, and Mar. 24, 1970, through May 31, 1970

*** Sept. 10, 1969, through May 31, 1970



NOTE: The percent of total occurrences represents the percentage of samples that fell within the specified concentration range during the entire sampling period.

FIG. 2 - OCCURRENCES OF HI-VOL CONCENTRATIONS

non-burning conditions, the geometric mean concentration for the sampling period was 41 $\mu g/m^3$. This value would probably have been reduced if the sampling period had included the summer months, because data from the Palm Beach County Health Department indicates lower concentrations during this period.

Morphological examination of the samples taken during the burning season resulted in observations of 15 to 54 weight percent burned plant material. During the non-burning season the range was 4 to 14 weight percent. Included in these figures were particulates from cane processing operations as well as particulates from any other vegetation burning.

Using data which were collected on wind direction and velocity as well as information on location and duration of burning cane fields, station locations were identified for each day of operation in which three or more were in a narrow sector affected by only one burn or a clustered group of burns. An attempt was made to correlate station location and distance from burn with suspended particulate concentration. No correlation was found.

Since, on any given day of operation, one location may have been exposed to the particulate from several different burns, the total time of possible exposure for each location was calculated. An attempt to relate this information to suspended particulate concentration for each station for each day of operation also resulted in no apparent correlation.

The observed values, when adjusted for the lower concentrations which are said to occur during the summer months, are well below those which are related to any adverse effects on health or materials even in the presence of substantial concentrations of sulfur dioxide. Occasional 24-hour concentrations were noted which would indicate possible interference with visibility. Six of these occasions were noted during the burning season and six during the non-burning season.

Sulfur Oxide Data. The maximum observed sulfation rate outside of West Palm Beach was 3.2 μg SO_3/cm^2/day and the minimum 0.01. The maximum geometric mean of the sulfation rate that occurred during the sampling period was 0.51 μg SO_3/cm^2/day, and the minimum value was 0.16 μg SO_3/cm^2/day. This is an indication of an extremely low level of sulfur dioxide exposure, far below any adverse health effects even in the presence of particulate matter.

Aircraft Sampling. Several attempts were made to measure the rate of particulate emission from burning cane fields. Transverse and longitudinal paths were followed in each plume. The airplane was equipped with an optical particle counter with which it was possible to measure the number of particles in several discrete size ranges from 0.3 to 7 microns. The data collected were inconclusive.

General observations were that a quantity of large particles fall out on the cane fields as soon as they are released from the thermal updraft. Some large particles were carried to several thousand feet before settling began. The upper air plume contained quantities of micron and sub-micron particles. The rapidity with which the volume of the plume changed made it impossible to obtain significant concentration traverses.

CONCLUSIONS

The results of the most comprehensive evaluation of air quality ever conducted in this area indicate a very good quality of air as measured by some of the common indicators of air pollution. Three of the 34 stations used were in locations common to those of the Palm Beach County Health Department. Data collected by this survey at the common stations compared well with data collected by the Department.

The most important finding was that the average suspended particulate matter concentration during the entire survey was less than 41 $\mu g/m^3$ (annual geometric mean). This represents a very good quality of air which is better than the lowest criteria values developed by NAPCA. Comparison with the NAPCA criteria values is even more favorable when it is considered that the NAPCA values assume the presence of appreciable quantities of sulfur dioxide. The observed SO_2 levels both in this survey and the survey by the Palm Beach County Health Department were very low. SO_2 levels are well below those which indicate impaired air quality according to NAPCA.

Little difference was noted in average values of suspended particulates between the east and west parts of the surveyed area and between urban and rural areas. Little difference also was noted in the weight of material collected by the samplers during periods when the sugar cane fields were being burned and when they were not, although the makeup of the material was different at the two times. The maximum weight percent of the burned vegetation (which may or may not be attributed to cane burning operations) observed at the 34 sampling stations was about 50 percent. The remaining was dust, sand, and other naturally occuring materials. Occasionally excursions to nuisance levels of particulate concentrations were observed both during the period when cane was being harvested and when it was not. These high levels are included in the calculated average concentrations.

The general conclusions which can be drawn for the nine month study is that although the sugar cane industry, along with other natural and man made sources, occasionally may be the cause of nuisance levels of particulate matter and dustfall, the observed air quality in the area is far from being detrimental to the health or property of man.

THE BUTTERFLY CONTROL VALVE IN THE SUGAR INDUSTRY

by

Jose J. Mecsery, P.E.

Connell Associates Inc., Consulting Engineers

"A PRACTICAL DISCUSSION ON
A VERSATILE CONTROL ELEMENT:
THE BUTTERFLY CONTROL VALVE."

THE BUTTERFLY CONTROL VALVE IN THE SUGAR INDUSTRY

We have seen a rapidly increasing use of the butterfly control valve as a final element for controlling flow of fluids. We have seen it in the sugar industry where controlling flow of fluids is required. We have also seen the increasing use of butterfly valves as shut-off valves replacing gate valves, plug valves, etc. These are simple valves operated by hand, as opposed to the control valve which is operated by an actuator and in most cases is throttling or controlling the fluid. Many manufacturers are now making this type of valve from many varied designs for practically all applications found in most industries, including the sugar industry.

Butterfly valves are apparently a simple control valve but often fail to operate satisfactorily because they were not properly specified to the manufacturer. A discussion like this hopes to review the practical engineering application data that should be applied to a butterfly valve selection and to help the user in answering the manufacturer's questions.

CONSTRUCTION CONSIDERATIONS

The design and construction of the butterfly valve is responsible for many of the advantages of this type of control valve. The advantages are its simplicity, its light weight, less installation time, less maintenance, and finally the most important of all; it costs less. The cost difference when compared to other types of valves is more pronounced as the size increases and when we need special material for body and trim.

The way the butterfly valve is constructed can be classified as follows:

By the method of operation-actuators. (Control valves only.)	(Electric operated actuators	
	(	
	(Pneumatic	(Diaphragm
	(Operated	(Piston
	(	
	(Hydraulic operated	
By the method of installation	(Waffer	
	(Threaded Lugs	
	(Flanged	
	(Welded Ends	
By the method of closing	(Metal to metal----Metal body	
	(and metal disc	
	(Bubble tight	(Flexible liner
	(shut-off	(Non-collapsible
	((rubber liner)	("0" Ring
	(Special Seal-Pneumatic Seal	

Discs can be flat or streamlined. The bearings can be inboard for low temperature fluids while outboard bearings are needed for high temperature fluids, steam, and special fluids.

In addition, the material used in the construction is important. Shafts, discs, body, elastometer when used, should be specified for the particular application.

Combining one of each of the above groups of classification we see the great number of different types that can be selected for a great number of applications. Briefly and in general, for liquids at low temperature requiring tight shut-off, the "Bubble Tight Shut-off" type with flexible liner or non-collapsible liner is used. For applications involving hot fluids or steam and where positive shut-off is not of importance, the metal seat is used. Material selection for body and trim as well as the elastometer for lined valves depends on the type of fluid to be handled, its operating characteristics such as pressure, temperature, pressure drop across the valve, material in suspension, etc.

THE BUBBLE-TIGHT SHUT-OFF BUTTERFLY VALVE:

This is perhaps the most common or popular type of butterfly valve in use today. "Bubble Tight Shut-Off" is a term used for the rubber seated butterfly valve and the meaning of it is seldom explained. The American Water Works Association (AWWA) in their specification for Rubber Seated Butterfly Valves (AWWA C 504-66) describe the test required for this type of valve. The test for the class 150 consists of having the valve closed in a horizontal position and air pressure of not less than 150 psi applied under the disc. The upper surface of the disc shall be visible and covered with water to form a pool at atmospheric pressure. Under above conditions that shall be for not less than five minutes no bubbles shall be seen past the valve disc. See Fig. No. 1.

There are basically two types of resilient lined valves used as control valves. The flexible liner is a replaceable and rather thin liner. It fits exactly in the valve body and sometimes bonded when the valve is to operate under vacuum. The non-collapsible liner is a thicker liner bonded to a plastic center ring and the whole piece fits like a ring inside the metal body. See Fig. No. 2. In both cases the liner is extended so that the elastometer is used as a gasket face. This makes additional gaskets for the companion flanges unnecessary and keeps the flowing medium from being in contact with valve body.

The other type of bubble tight shut-off valve is the one using an "O" ring on the disc and "O" rings for sealing as gaskets. One manufacturer does not recommend this type for throttling service as is required for control valves.

A great number of different elastometers can be used for many and different applications. The most common being Natural-Rubber, Neoprene, Hypalon, Buna-N, Viton, Thiokol, Butyl, etc., depending on the requirements of temperature, pressure, fluid type, composition, and rate of flow. With these elastometers and a proper selection of shaft and disc, a wide range of service temperature (-30 to 300 degrees) and a wide range of hard to handle fluids is normally and successfully handled.

DYNAMIC CONSIDERATIONS

The best illustration we can give of what happens inside a butterfly valve when partially open is when we compare it to a wing of an airplane. Here instead of the valve moving airplane), the fluid moves. So it is more like what happens with a model airplane in a wind tunnel.

The total forces due to differential pressure across the disc (due to the difference in velocity of trailing and leading edge) creates a torque that tends to close the valve. The torque is practically zero when the disc is at zero degree (valve closed) and at 90 degree open. The torque increases as the valve opens and reaches maximum when the valve disc is about 75 degrees open. This is illustrated in Fig. Nos. 3 & 5. Here it is essentially good to remember that butterfly valves are only balanced in a closed position (0 degree open) and at the wide open position (90 degrees open) contrary to the rather common belief that butterfly valves are completely balanced valves. It is also good to remember that to go from 0° open to 90° open the disc has to pass through the maximum torque at about 75° open. This would be the case of a valve operating "on" and "off" from closed to wide open position. Valve and operator should be selected for the maximum flow and corresponding maximum torque.

The maximum torque determines the maximum pressure drop the valve cane withstand and in turn determines the size of the operator. Most valve manufacturers rate butterfly valves for the allowable pressure drop across the valve in the closed position and at various angles of opening. These ratings are independent of the body working pressure rating.

A given value of a particular material for body, disc and shaft may be listed to have an allowable pressure drop of 197 psi at 0° open, 134 psi at 30° open, 29 psi at 60° open. The valve body may be rated at 150 psi for standard ASA flanges of 150 psi. If the line pressure is not higher than 150 psi the valve will withstand the pressure of the fluid in the closed position and if the pressure drop at maximum flow (at 60° open) is less than 29 psi, the valve is suitable for the service.

Fluid velocity in pipe lines where butterfly control valves will be used should be check. By experience, the velocity should be limited to a maximu of 20 fps. for liquids (AWWA limit is 16 fps. at valve 90° open) and 20,000 to 25,000 fpm. maximum for air or gases. Fluid velocities in the pipe line exceeding these valves will result of poor control, erosion, cavitation, high torque, noise, etc., to mention but a few of the problems that may appear.

FLOW CHARACTERISTICS

The success of the butterfly valve as a control valve comes from the fact that the flow characteristic of the butterfly valve is very close to an "equal percentage" which is the ideal one for control valves on most all throttling applications.

The curves at Figure No. 4 shows the different flow characteristics curves comparing butterfly valves with those special contoured control valves most frequently used.

Because of the flow characteristic and the dynamic torque increasing to a maximum of about 75° open, the control valves are limited to a maximum of 60° open. This is a general practice and adopted by all manufacturers. Valve openings from 60° to 90° is unreliable for throttling service.

All valve manufacturers publish or would furnish upon request their actual sizing coefficients, Cv, Cs, and Cg, for liquids, steam and gas respectively. These coefficients are given for different degrees of opening including the 60° or maximum for throttling and 90° for those which will operate "on" and "off."

CAVITATION

As with centrifugal pumps, cavitation may be found using a control valve of high-recovery as is the case of the butterfly valve.

Cavitation in a valve is a two stage phenomenon. When handling liquids there may exist zones where the pressure is below the vapor pressure, then the vapor bubbles appear. This happens markedly in a control valve where the reduction in pressure is accompanied by an increase in velocity. This is the vena-contracta of the valve's restricted area. This may be called the first stage.

The second stage is when the bubbles move to a zone at lower velocity and higher pressure thus recovering some of the lost pressure.

Due to the fact that the bubbles cannot exist under this condition, the bubbles collapse or "implode" creating the characteristic crackling sound (like gravel flowing thru) of cavitation. When this happens, the high pressure shock waves originated by the great number of collapsing bubbles if near a metal surface minute blows strike the metal surface. This action repeated in time fatigue the metal until minute metal flake particles are washed away. This action repeated by the large quantity of those minute blows is what becomes known as physical damage to the valve and or the pipe downstream from the valve.

THE LOW TORQUE BUTTERFLY VALVE----A NEW DEVELOPMENT

A couple of manufacturers have developed a "special disc design." With this design the torque has been reduced to the extent that it has been possible to increase the opening range to 90° open and still maintain the torque at approximately the same (or lower) value the one corresponding to 60° or 70° opening of the conventional design. The newly developed design has also corrected the flow characteristics so favorably that the operation at openings greater than 60° and up to the maximum of 90° opening has been very satisfactory.

Tests have been made in order to provide accurate prediction of torque, capacity and cavitation characteristics for practically any valve size.

The flow-torque characteristic of these newly developed discs are compared to the standard or conventional disc in Figure No. 5 and the shape of two known types are snown in Figure No. 6.

As additional information on this new development, one manufacturer informs us that their disc is designed for only metal seat valves, the other manufacturer claims that their disc works well in both unlined and elastometer lined valves.

BUTTERFLY CONTROL VALVES USED IN THE SUGAR INDUSTRY

To demonstrate that the butterfly control valve has been successfully used in many stages of the process in the sugar industry, the following is a list of butterfly control valves actually in use in one large modern raw sugar factory.

COLD RAW JUICE Raw Juice Level Control D.S.M. Level Control	Rubber lined with stainless steel disc and shaft.	Throttling
HOT CLARIFIED JUICE & LIGHT CONCENTRATED Pre-evaporator & Multiple effect juice level control.	Cast iron body, bronze liner and stainless steel shaft and disc Metal seat	Throttling
SYRUP (MELADURA) Syrup Density Control	Cast iron body, bronze liner and stainless steel shaft & disc. Metal seat.	Throttling
CONDENSER WATER Vacuum control of Evaporators & Vacuum Pans	Cast iron body stainless steel disc & shaft. Metal seat.	Throttling
STEAM CONDENSATE Condensate tanks level control	Cast iron body Stainless steel disc & shaft. Metal seat.	Throttling
LOW PRESS. & EXHAUST STEAM a) Control excess exhaust steam b) 20 to 10 psi P.R.V. c) Steam control to Vac. Pans and 1st bodies of Evaporators.	Cast iron body Cast iron disc Stainless steel shaft Metal seat	Throttling
d) Steam control to the Pre-evaporator	Cast iron body Stainless steeel disc and shaft Reduced trim Low torque disc, Fishtail type.	Throttling
DEEP WELL WATER Ash handling system (corrosive water with suspended matter)	Steel body Rubber lined with flexible liner. Stainless steel disc and shaft.	"On - Off"

REFERENCES:

I Carl D. Wilson - Fishtail vs. Conventional Discs in Butterfly Valves - Instrument & Control Systems - March, 1968

II H. W. Boger - Low Torque Butterfly Valve Design. Instrumentation Technology - September, 1970

III Albert J. Hanseen - Butterfly Valves
Power - January, 1966

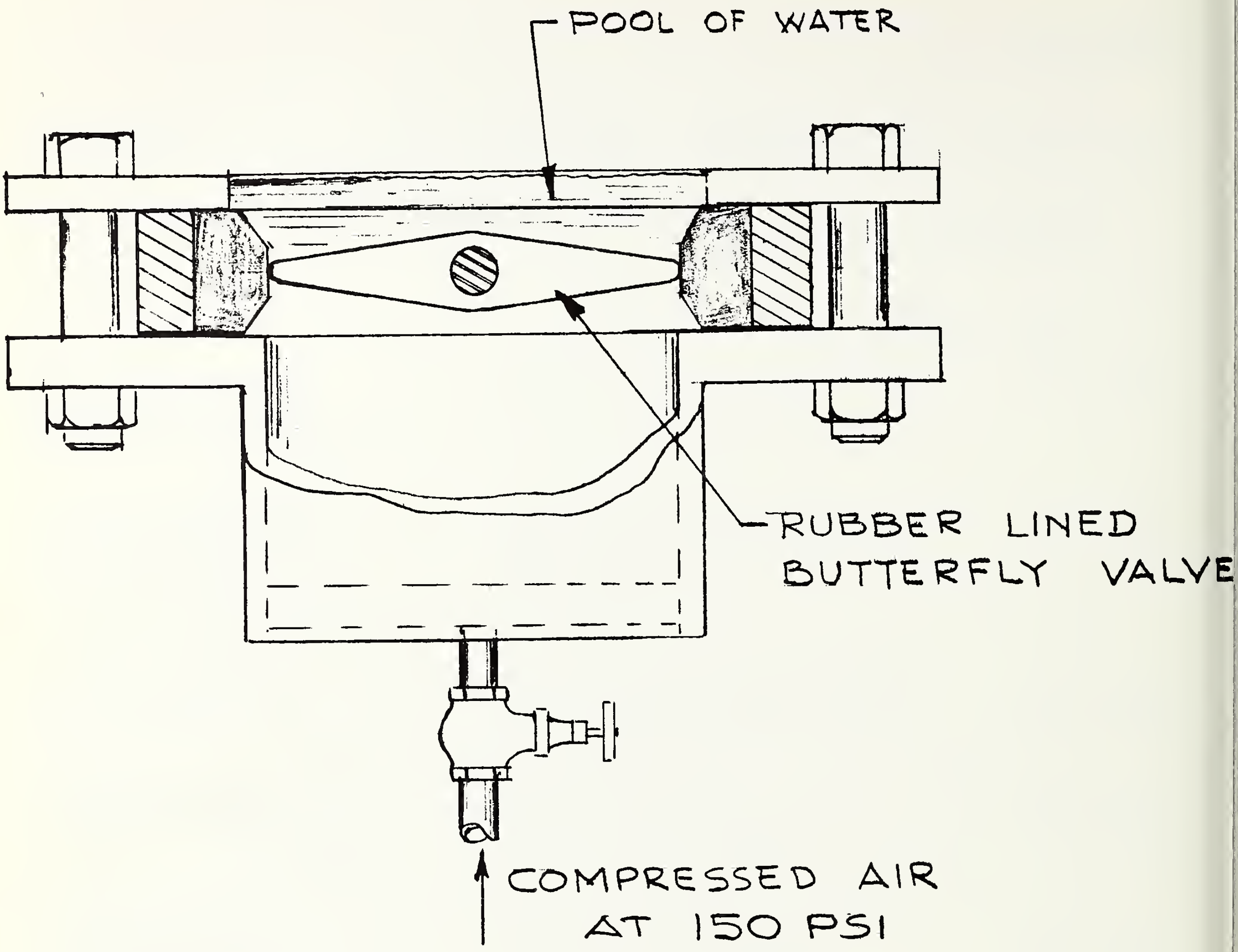
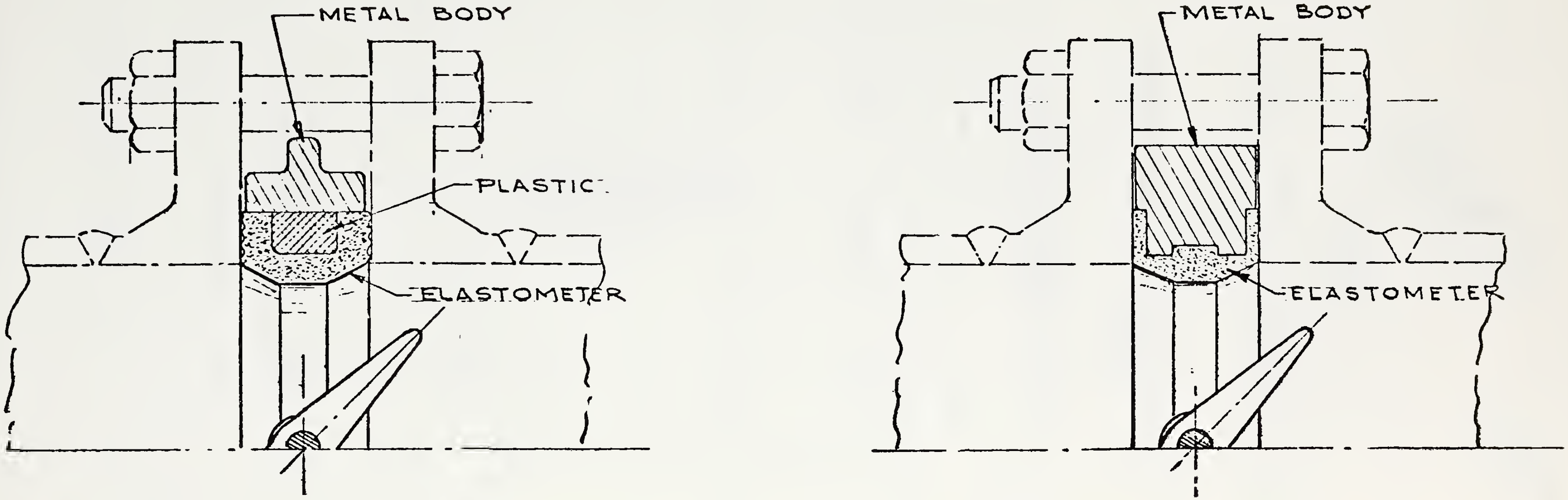


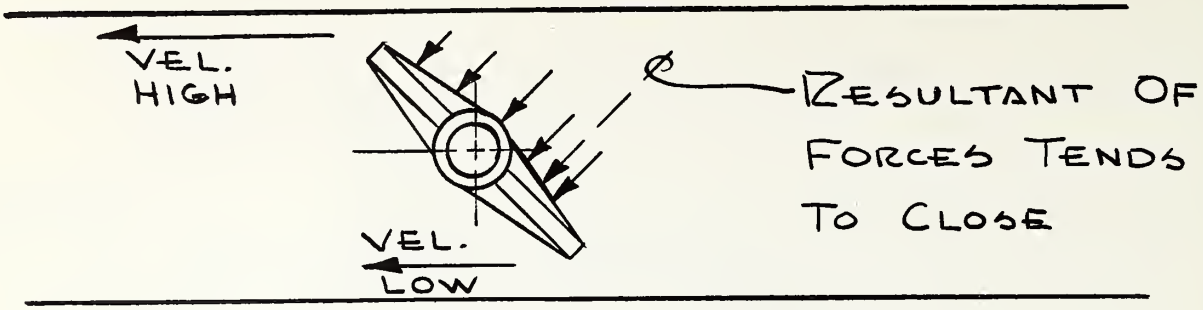
FIG. Nº 1 BUBBLE-TIGHT SHUT-OFF TEST FOR RUBBER LINED BUTTERFLY VALVES



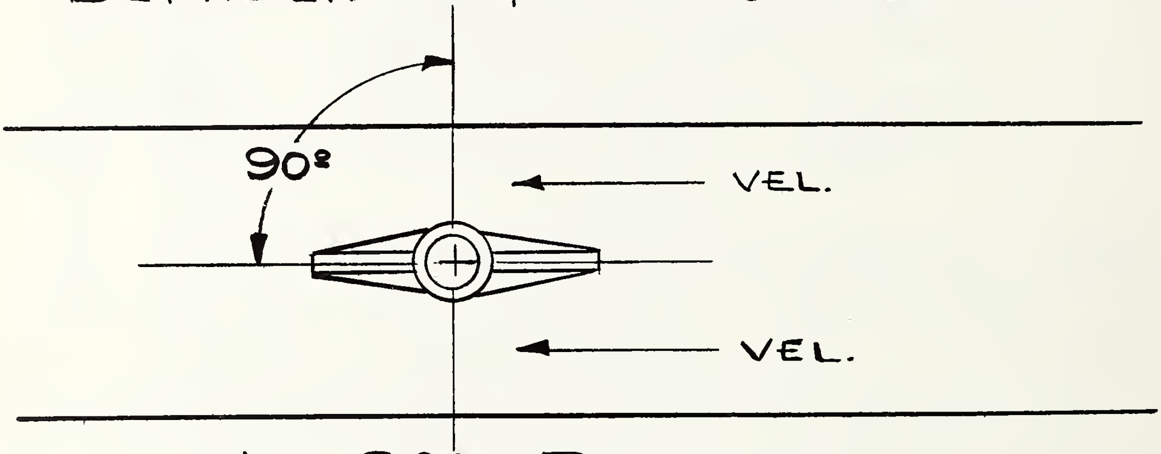
a) NON-COLLAPSIBLE LINER

b) FLEXIBLE LINER

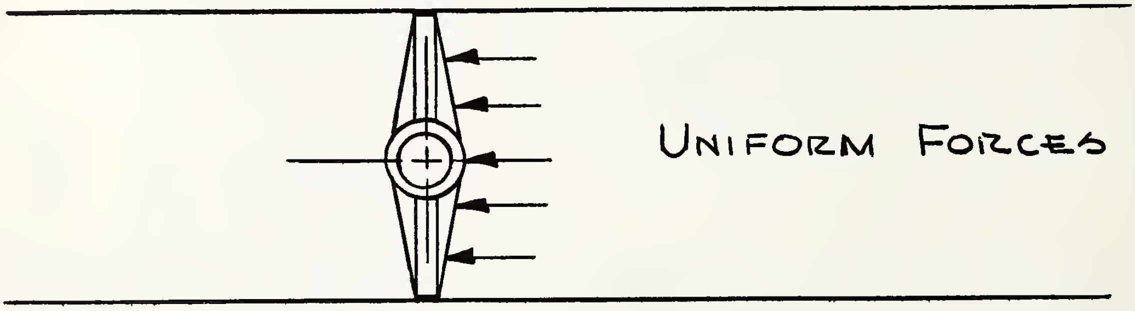
FIG. Nº 2. LINED VALVES



BETWEEN 0° & 90° - UNBALANCED



AT 90° - BALANCED



AT 0° - BALANCED

FIG. N° 3 FORCES ACTING ON THE DISC

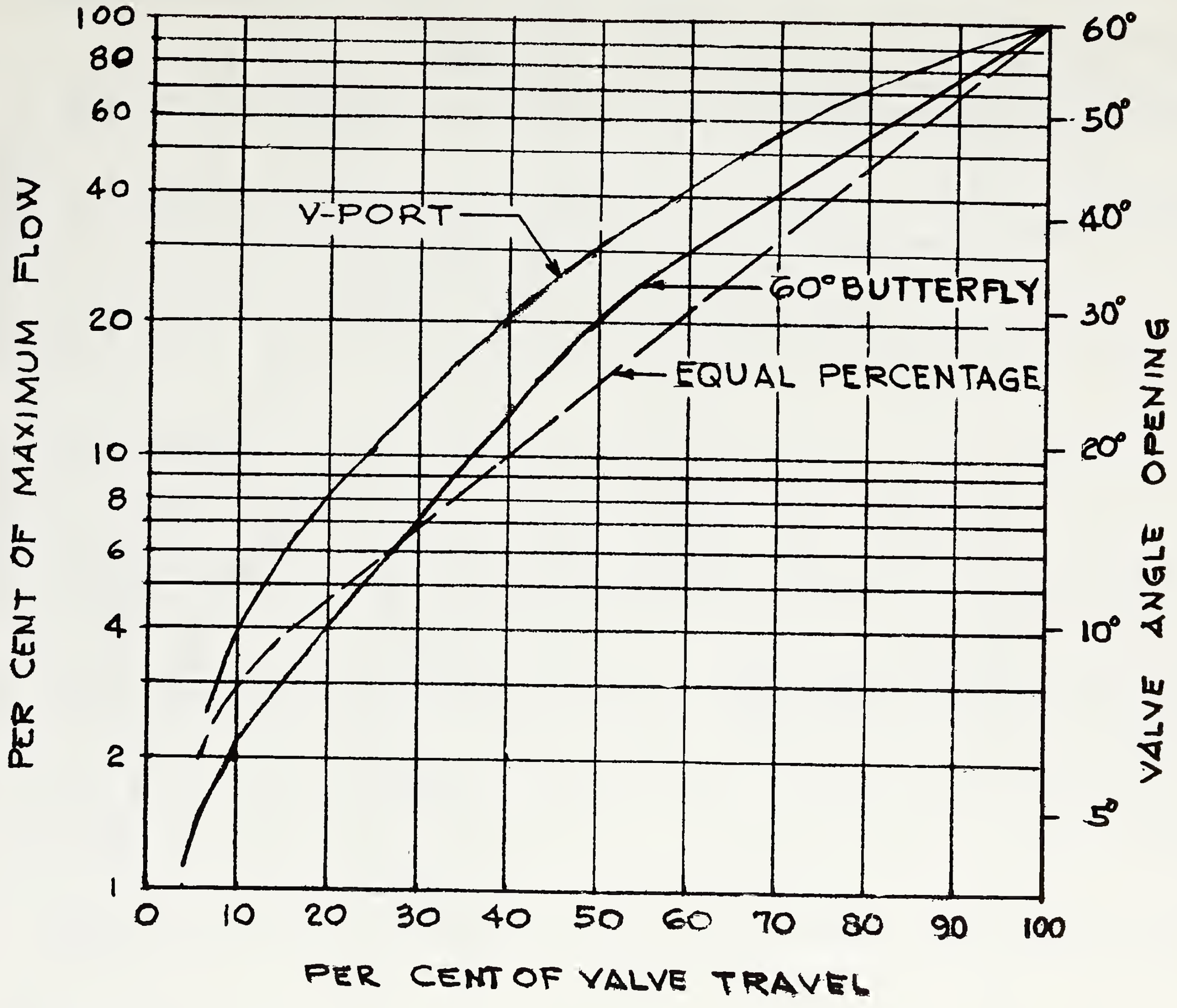


FIG. Nº 4 COMPARISON OF FLOW CHARACTERISTICS

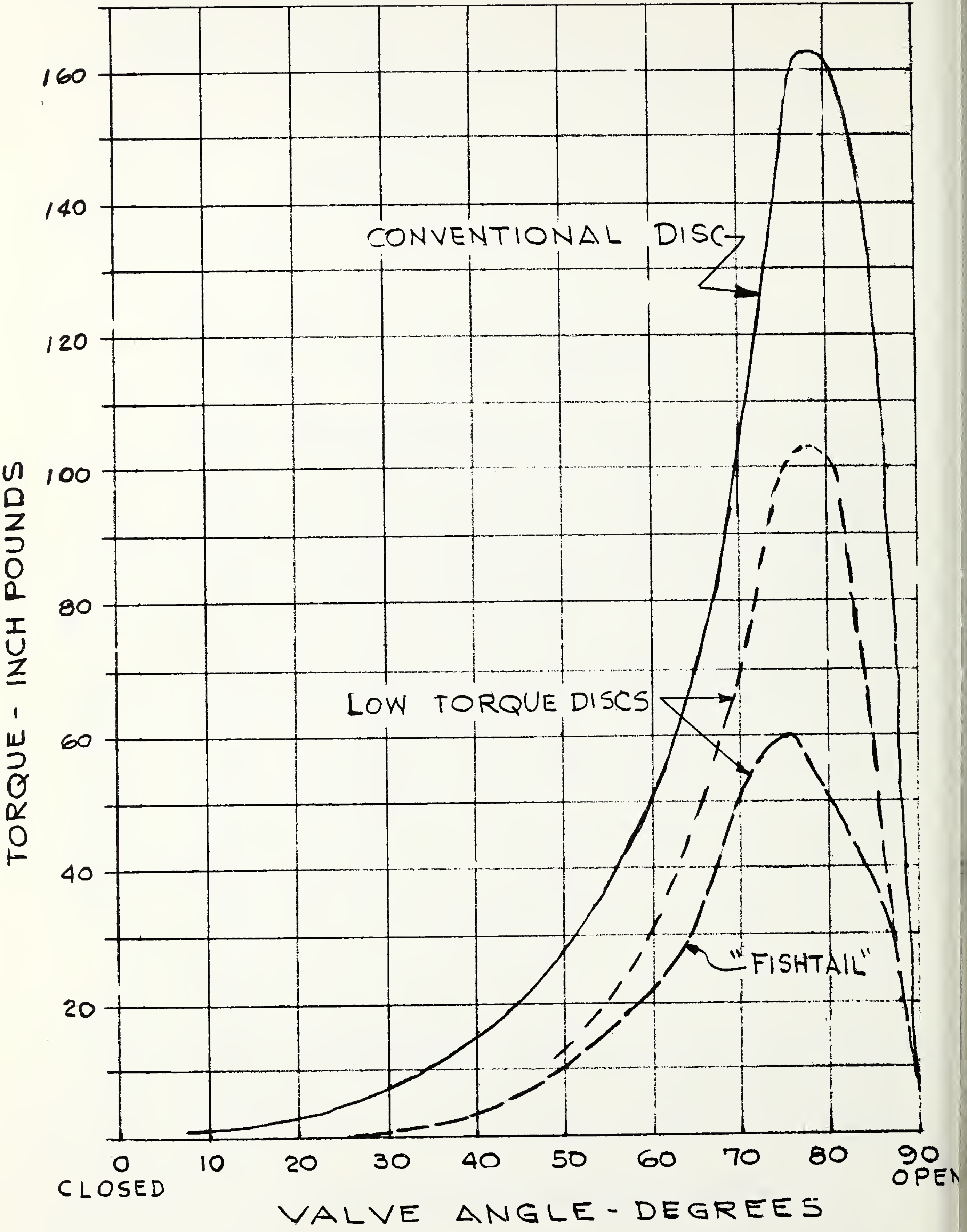
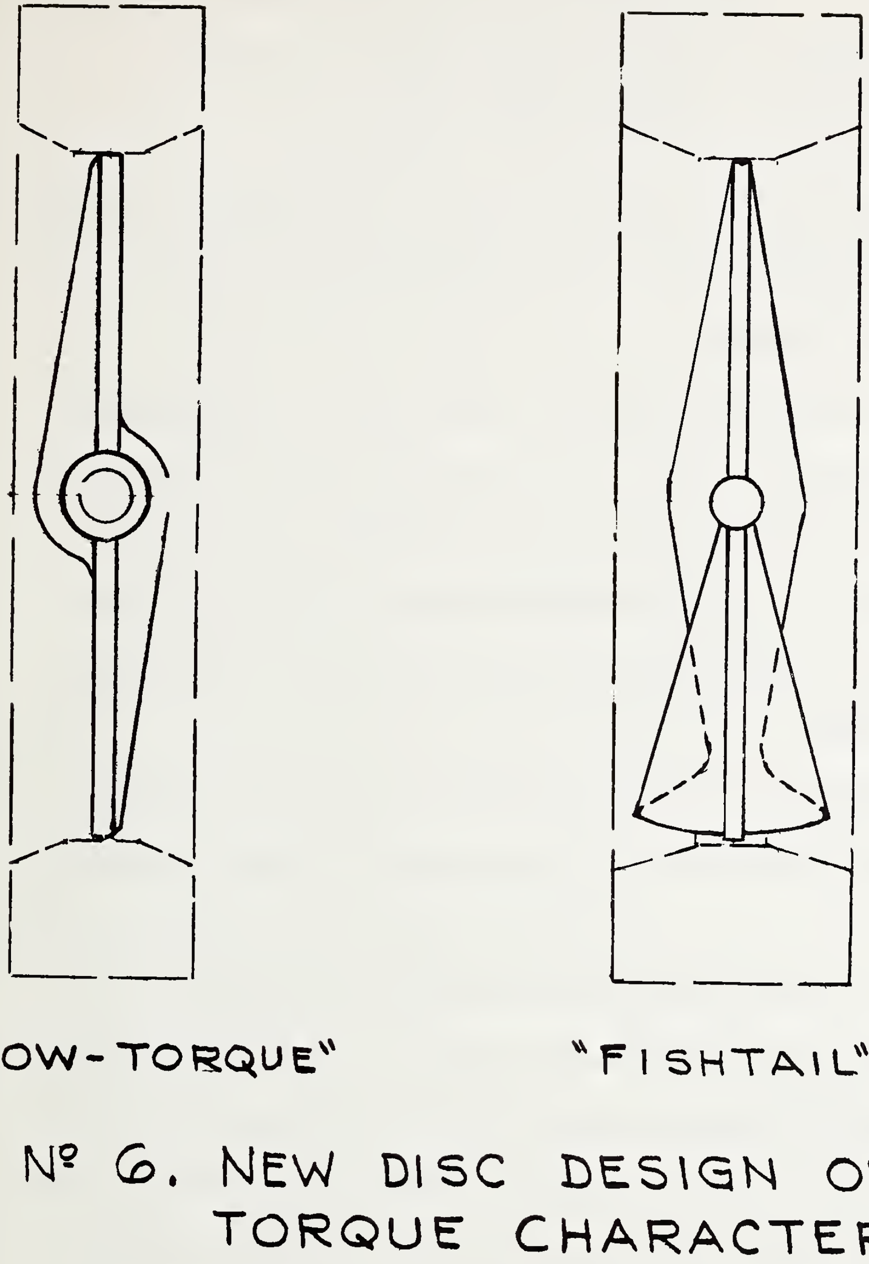


FIG Nº 5 TORQUE CHARACTERISTICS OF BUTTERFLY VALVES


"LOW-TORQUE"

"FISHTAIL"

FIG. Nº 6. NEW DISC DESIGN OF LOW TORQUE CHARACTERISTIC

REVERSE CYCLE TO ESTABLISH FOOTING FOR COMMERCIAL SUGAR

By:

GERARDO F. FUNDORA, MEMBER AICHE

The accumulation of precipitated impurities are found in greatest quantities in the final products of a raw sugar factory, specifically C sugar and final molasses.

The use of C sugar as footing for commercial boilings has been objected for many years. Due to its fineness an extremely high percentage of precipitated impurities are trapped by the sugar layer in the centrifugals. So it is obvious that the returning of these impurities to the commercial boilings is a direct contamination to the commercial sugar.

How to minimize the risk of getting these impurities into the crystals? I would say by using a Reverse Cycle to establish footing for the commercial boilings. By establishing the grain in a low purity medium in which the velocity of crystallization is slower, the risk of conglomerates and twin grains are minimized. Once the full seeding is done the technique calls for up-grading the mother liquor purity by feeding syrup, the velocity of crystallization will start to raise speeding up the formation of the footing and the layers of sucrose depositing on the grain will come out from a richer solution.

I called this technique Reverse Cycle because it is quite the opposite of what is usually done; which is either graining a high purity medium and de-grading the mother liquor purity by feeding low grade molasses with the risk of imperfect sucrose crystals and the danger of syncrystallization, or graining low purity medium and continuing with the feeding of same high viscosity and low purity material until the footing is established.

Two types of impurities are perfectly defined in sucrose crystals:

a) The impurities absorbed by the growing crystals, a phenomenon which is known as syncrystallization.

b) The occlusion of impurities in pockets, cavities, grooves, etc. which occurs when we have the formation of conglomerates.

The Reverse Cycle uses the full seeding on low purity medium guaranteeing a great uniformity of crystals. The crystals are fed with high purity material and developed into commercial size by cutting to seend tanks and between vacuum pans. Using fondant seed with an average grain size of 15u would require a weight development of 296,000 : 1 to obtain commercial sugar of 1:00 mm.

C massacuite is made out by seeding A molasses and continuing its development with same low purity material. The C sugar is not used as footing for the commercial boilings and is melted in the clarified juice tank.

Which is the drawback in using the outlined procedure? It could be said a higher consumption of steam in the boiling house due to the melting of the total C sugar produced, but actually on any boiling system in order to meet the standard grain size some 50-60% of the C sugar is melted. In our case it was proven that there was no significant increase in steam used according to the records kept while running the trial tests. What are we going to accomplish by using the Reverse Cycle? Essentially by establishing the grain in a low purity medium most perfect crystals are formed and by switching to a higher purity material once the grain is visible less color and a reduction of insoluble ash is obtained.

The preceding was confirmed during the 1969-70 crop when five trial periods were run collecting samples of the raw sugar for color and ash determination.

Our standard improved Two Boiling System was used throughout the trial periods using either C sugar as footing or the Reverse Cycle technique. The composite samples of the raw sugar manufactured were analized before and after being affined showing the following results:

%Ash, Sulphated

	Original Raw Sugar	Affined Raw Sugar	% Removed
C sugar as footing	0.40	0.19	52.50
Reverse Cycle technique	0.32	0.14	56.25

Color Index, Determined at 560 mu

	Original Raw Sugar	Affined Raw Sugar	% Removed
C sugar as footing	42	5	88.10
Reverse Cycle technique	44	2.6	94.10

Raw Sugar Factories with high color and ash content in their commercial sugar could reduce them by using this technique.

WORK DEVELOPMENT IN VACUUM PANS TO ESTABLISH THE REVERSE CYCLE

Calculations:

Step #1 Seeding for 24 "A" strikes with 6.25# of Fondant seed.

400 cu ft A molasses

800 cu ft Syrup

1200 cu ft x 83.092 # sol. @ 90° B x 37.5% crystal content = 37,391# crystal

Weight Development 37,391# ÷ 6.25# = 5,982 : 1

Grain Size .015 mm $\sqrt[3]{5,982}$ = .272 mm

Step #2

1200 cu ft

600 cu ft cut to seed tank #1 for 12 strikes.

600 cu ft 37,391 # ÷ 2 = 18,696# of crystals in footing.

600 cu ft Syrup

1200 cu ft 83.092# sol. @ 90° B. x 47.5% crystal content = 47,362# crystals

Weight Development 47,362# ÷ 18,696# = 2.53 : 1

Grain Size .272 mm $\sqrt[3]{2.53}$ = .370 mm

Step #3

1200 cu ft

800 cu ft cut to seed tank #2 for 8 strikes.

400 cu ft 47,362# ÷ 3 = 15,787# crystals in footing.

6400 cu ft Syrup to make up 4 strikes, 1700 cu ft each.

6800 cu ft x 88.451# sol. @ 94° B. x 51.5% crystal content = 309,755# crystals

Weight Development 309,755# ÷ 15878# ≐ 19.62 : 1

Grain Size .370 mm $\sqrt[3]{19.62}$ = 1.00 mm

Total weight development of the crystals:

1,850,000# crystals ÷ 6.25# seed = 296,000 : 1

As the size of the grain used for seeding must be proportional to the reciprocal of the cube root of the increase of weight, the powder used must have a grain size of:

$$1 \div \sqrt[3]{296{,}000} \times 1.00\text{mm} = .015 \text{ mm}$$

THE SCREW PRESS IN THE SUGAR INDUSTRY PRESENT STATUS AND POTENTIAL

by

Francis C. Schaffer
F. C. Schaffer & Associates, Inc.
Baton Rouge, Louisiana 70806

October 15, 1970

Screw presses have been used extensively since the turn of the century to extract various oils and juices from vegetable products. A mill tandem serves a similar purpose as it also expresses juices from vegetable materials, so it may be somewhat surprising that screw presses were not used in the sugar industry sooner. Of necessity, this discussion will focus mostly on the press developed by the French Oil Mill Machinery Co. for two reasons - (1) it is the press that has gained general acceptance in the industry and is familiar to Florida sugar people and (2) I have been an interested onlooker of the development of the French press. It should be noted that several other manufacturers also have developed or are working on the development of screw presses.

I first became interested in the application of screw presses to the sugar industry in 1953-54. At that time, I was working for National Cylinder Gas Company as project engineer on a vertical cane sugar diffusion project at Fellsmere, Florida, when they were testing the diffuser developed by Mr. W. P. Sevin and Mr. Marshall Stewart. Our 100 TPD pilot plant had been successful in achieving 97-98% extraction when my boss, Mr. Stewart, advised me that National Cylinder Gas did not feel the market potential sufficient unless de-watering equipment independent of conventional mills could be offered along with the diffuser. I toured the country investigating many types of de-watering devices and reached the conclusion that the only device rugged enough to process cane or bagasse was the French Oil Mill Machinery Company screw press that was used to extract vegetable oils. I arranged a meeting with Mr. A. W. French, President of the Company and he became enthusiastic about trying to adapt his oil mill press to de-water bagasse. In fact, in Chicago, we even discussed the possibility that a series of screw presses might prove as efficient as a diffuser in extracting sugar juices from cane. Mr. French agreed to run samples of our spent diffuser chips in one of his vegetable oil presses. The management of Fellsmere sugar factory assisted in shipping a small drum of exhausted diffuser chips to French in 1954. The small vegetable oil press was successful in reducing the moisture content of the sample from 80% to 41% in the first run. Subsequent tests reduced the moisture content to less than 35%. However, as I remember it, the capacity of this vegetable oil press was very limited and power required was in excess of 50 HP per ton of cane per hour. It was obvious that the vegetable oil press could do the job but that a practical size installation would require an excessive amount of press equipment and power. However, French was encouraged enough with the results to continue to work on the project with the objective of manufacturing a press that could handle wet diffuser bagasse with a reasonable amount of power.

National Cylinder Gas later sent me to see Dr. Arthur G. Keller to arrange to prepare a drum of sugar cane chips at the Audubon Sugar Factory for French to use for further testing in 1955. Mr. Al Burner and Mr. Burt Starett of French Company ran the 55 gallon drum of wet sugar cane chips through the modified vegetable oil press, producing a cake almost as solid as wall board--it contained only 25% moisture and practically no sugar. However, the capacity was low and the power required was still excessive, something over 40 HP per ton of cane per hour, or about 300 HP per ton of fibre per hour according to some old notes I made at the time.

In 1956, a modified French Oil Mill screw press was installed at one of the Louisiana factories to determine the feasibility of using screw presses for de-watering bagasse or diffuser chips and also as a possible alternate means for milling sugar cane. The press operated fairly well, lowering moisture to about 45%, but the volume of material involved in a sugar factory still seemed colossal in relation to the capacity of screw presses available at the time and the power was still in the range of 21-25 HP per ton of cane (150 to 175 HP per ton of fibre) per hour.

In 1957 the press experiments were moved to Florida to take advantage of a longer season. In two seasons in Florida the press was tested on mill bagasse, cane, cush-cush and filter mud. The physical results seemed encouraging but the capacity of the modified vegetable oil press was much too small for the anticipated volume and power requirements were still much too high. In 1958, French worked with the screw press in Hawaii and made significant advances towards increasing capacity and reducing HP although power consumption was still too high.

In 1960, National Cylinder Gas Company had Mr. Sevin and myself build a 500 TPD vertical diffuser for installation in Trinidad. The engineering of the installation was performed by a company who purchased an English-made screw press. Although the diffuser worked fairly well, achieving extractions of 95.5 to 98.2%, some mechanical problems were encountered, the auxiliary equipment contributed to a number of stoppages, and the screw press installed for de-watering was not entirely satisfactory. It is significant that at this point the technically successful diffuser was abandoned, partly because of the lack of suitable de-watering equipment, while the French Oil Mill Machinery Company continued with their work to adapt their press to the cane industry.

In 1963, a redesigned French press was installed at Pioneer Mill in Hawaii to dewater bagasse from the pilot plant Silver Ring Diffuser. This press operated at a rate of 15-20 tons of cane per hour and required only about 7 or 8 HP per ton of cane to reduce the moisture content to a range of 47-50%. The following year French designed a completely new and larger screw press, incorporating what they had learned in the preceeding years. In 1965, this press was successful in handling the diffused bagasse from up to 100 tons of cane per hour with a 600 HP drive. This press was designated their model J-88.

In 1966, a modified J-88 press was installed at the Clewiston factory in Florida to improve sucrose extraction by further processing the bagasse from the mill tandem. Although there were some difficulties, this installation indicated that a screw press could successfully reduce the content of sucrose in bagasse even from the low levels resulting from a good milling operation. This press was then moved to Grove Farms where additional improvements were made.

French has further improved their model J-88 press and come out with larger models K-70 and K-88 as well as specialized cush-cush presses. There are now over a dozen commercial size installations in the sugar world and more are being considered for dewatering diffuser bagasse, for increasing mill extraction and capacity and for de-watering cush-cush. Thus, in the relatively short time of about 15 years, the screw press has developed to the point where it must be given serious consideration in expanding or improving sugar cane extraction units.

The French screw press is basically simple. Bagasse is dropped into an independently driven feed screw that compresses and delivers it to the main interrupted flight type press worm that operates on the same centerline. The worm operates within a cylinder-screen through which the liquid is expressed. The worm is driven at a moderate RPM by an integral triple reduction gear. Compression of the bagasse and expression of the liquid is accomplished by a combination of step-wise decreasing cylinder-screen diameters, increasing worm shaft diameters and a tapered cone held against the discharge orifice by adjustable hydraulic pressure. The cylinder screen is actually formed of hardened stainless steel bars set on edge with a slight space between them as no conventional screen could withstand the tremendous pressures developed. The bars are parallel with the center line of the worm. The cone held against the discharge orifice is also an inwardly draining screen that removes the final liquid expressed. A typical large press rated at approximately 30 tons of fibre per hour is driven with a 1500 HP steam turbine, uses 30 to 35 HP per ton of fibre per hour, and weighs about 75 tons.

In using a screw press to improve the extraction of an existing mill tandem by processing the bagasse from the last mill, the operation is as follows: Bagasse is dropped from the main carrier into a special conveyor that mixes the bagasse with maceration water and carries the bagasse to the press. The maceration water is applied in this conveyor instead of ahead of the last mill(s). The pressed bagasse is then conveyed back to the main bagasse carrier. A gate arrangement allows the press to be bypassed. The expressed juice-water mixture (press water) is returned to the last mill(s) where it is applied as remaceration. Part of the press water can be recycled to the press to improve extraction at low maceration water rates.

Although the press water has a low purity typical of last expressed juices, the purity of the last mill juice is increased and, at the factory where we obtained preliminary data, the purity of the mixed juice and the overall yield of sugar as a percent of the sugar in the mixed juice remained constant as compared to straight mill mixed juices. If the purity of the mixed juice is lowered under specific operations, then, of course, all of the additional sugar recovered from the bagasse would not all be recovered but should be calculated using a suitable recoverable sugar formula in combination with the boiling house efficiency. Additionally, some extra costs are involved in processing and handling the additional sugar so that not all of the additional sugar recovered is profit. We have estimated these additional costs at 3/4¢ per pound.

The results obtained with a Model K-70 French Press at Moore Haven are as follows:

	Four 54-in. Mills and Two 78-in. Mills Alone		Mills Combined with Screw Press		
Crop	66/67	67/68	68/69*	69/70*	69/70 Days over 5000 TPD
Days	128	141	67	124	20**
Tons/24 hr.	4,097	4,172	4,591	4,435	5,182
Tons Fibre/hr.	19.7	18.6	22.1	20.6	21.8
Cane % Pol	12.02	11.93	10.81	11.11	11.31
Cane % Fibre	11.55	11.79	11.30	11.12	10.04
Bagasse % Moisture	53.53	54.39	53.56	54.19	54.21
Bagasse % Pol	3.54	3.64	2.74	2.43	2.44
Bagasse Pol % Fibre	8.57	8.95	6.34	5.75	5.84
Maceration % Cane	21.63	20.19	18.24	19.51	15.50
Maceration % Fibre	187.3	171.2	161.4	175.4	154.4
Extraction % Pol	91.80	91.14	94.02	94.24	94.79

* Includes periods when press was off line - estimated at 15% during 68/69 crop (after press was installed), and 7% of time in 69/70. Press operated last 67 days of 103 day crop in 68/69, entire crop in 69/70.

** Press operated 20 days at capacity between 5,000 and 5,440 tons cane/24 hr-distributed fairly evenly throughout last 3/4 of crop.

Although the screw press is reputed to produce 2.0 to 3.0 lower moisture % bagasse, we have observed that this occurs in high fibre canes but does not always hold true to a significant extent with low fibre cane. We have observed that an increase in thruput within equipment limitations does not significantly adversely affect extraction.

Results obtained at several mills are summarized below. Maceration rates averaged about the same for operations both with and without the press.

	Sucrose % Fibre		
	Mills	Mills and Press	% Reduction
Factory A			
Mills 67-68, Press 68-69	8.95	6.34	29.2
Mills 67-68, Press 69-70	8.95	5.75	35.8
Factory B			
Mills 69-70, Press 69-70	6.87	4.85	29.4
Factory C			
Mills 67-68, Press 67-68	9.49	5.83	38.6
Mills 68-69, Press 68-69	9.24	6.36	31.2
Mexican Factory			
Mills 1968, Press 1968	5.75	3.47	39.7

The formula used by French to calculate their guaranteed additional sucrose extraction is 1.2 x maceration % cane x sucrose in bagasse from tandem. They estimate the actual additional extraction at 1.7 x maceration % cane x sucrose in bagasse. Thus, for 20% maceration, an estimated 34% of the sucrose in the bagasse would be recovered by the press.

We have observed that the additional recovery is influenced by maceration % fibre as well as maceration % cane and that the following formula works pretty well under various fibre conditions.

$$\text{Additional sucrose extraction} = \frac{1.7 \times M\%\,C \times S\%B \text{ plus } 0.213 \times M\%F \times S\,\%\,B}{2}$$

Where M = Maceration, C = Cane, S = Sucrose, B = Bagasse, F = Fibre

It would seem that wear in a screw press would be excessive. There is considerable wear in the final section of the press. However, maintenance consists mostly of rebuilding and/or replacement of final sections of the worm and final section screen bars. Maintenance costs to date in Florida have averaged 2.2¢ per ton of cane. Lost time with the press has averaged about 2.5%. A double helix final worm section, improvements in the design of the final section and an improved cone design promise to reduce wear and power requirements. A hydraulic opening mechanism is now available to facilitate maintenance.

Projected financial return on a screw press when using 20% maceration on 12 1/2% fibre cane are as follows for a factory now producing 30% bagasse on cane containing 3.6% sucrose.

	500,000 Ton Crop		1,000,000 Ton Crop	
Total Installed Cost	$332,000		$332,000	
Additional Sugar	2,750,000 lbs.		5,500,000 lbs.	
Value at 8¢ per pound	$220,000		$440,000	
Costs:				
Depreciation (20 yr.)	$ 16,600		$ 16,600	
Interest (Avg. at 7%)	$ 11,700		$ 11,700	
Maintenance	$ 11,000		$ 22,000	
Processing added sugar at 3/4¢	$ 20,600		$ 41,300	
TOTAL COST		$ 59,900		$ 91,600
RETURN		$160,100		$348,400

I believe that a screw press to further process mill bagasse should be given serious consideration in any plan to increase mill capacity and improve mill extraction.

Another application of the screw press that can increase mill capacity and efficiency is to pass the cush-cush through a small screw press, as is being done in several factories. Some increase in capacity and extraction can be accomplished by passing the cush-cush through the press and applying the pressed cush-cush back on the mill tandem as wet cush-cush reduces capacity more than proportional to its fibre content. For a more substantial increase in capacity, the cush-cush can be taken from the tandem, processed in one or more screw presses with maceration, and taken direct to the bagasse carrier.

A screw press is a logical selection for de-watering bagasse from a diffuser, especially for a new installation where no mills are available.

Another possibility for the screw press is the pressing of filter-cake muds. Mud disposal has always been a problem and, with increased emphasis on the condition of our environment, this problem will become more acute. A press to dry the muds for either burning or to facilitate disposal may become necessary.

An application that has great promise is the use of a series of screw presses in place of a mill tandem. Based on extrapolation of existing data, I believe that a five-press tandem can achieve at least 97% extraction at 160 maceration % fibre. Some problems will be involved including the feeding of the initial press and the difficulty of by-passing a press which has more probability of lost time than a mill. With improvements of average lost time to 1% or less for a press now anticipated, the lost time would be about 5% which is getting close to low enough for consideration. Screw press tandems may well be seen in the not-to-distant future.

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